chapter iv

Refined Designated Uses for the Chesapeake Bay and Tidal Tributaries

BACKGROUND

Renewed Commitment to Restore Chesapeake Bay Water Quality

The *Chesapeake 2000* agreement and the subsequent six-state, District of Columbia and EPA memoranda of understanding challenged the Bay watershed jurisdictions to, "by 2010, correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act." (Chesapeake Executive Council 2000; Chesapeake Bay Watershed Partners 2001.)

These agreements included commitments to "define the water quality conditions necessary to protect aquatic living resources" and to have the jurisdictions with tidal waters "use their best efforts to adopt new or revised water quality standards consistent with the defined water quality conditions." Against this backdrop of a renewed commitment to restore Bay water quality (in part through the adoption of a consistent set of Chesapeake Bay water quality criteria as state standards), the Chesapeake Bay watershed partners recognized that the underlying tidal-water designated uses must be refined to better reflect desired Bay water quality conditions.

Current State Tidal-Water Designated Uses

Virginia, Maryland, Delaware and the District of Columbia have identified parts of the Chesapeake Bay and its tidal tributaries as 'state waters.' The current designated uses for these state waters are for the protection of aquatic life (Table IV-1; figures IV-1 through IV-4). The accompanying current criteria addressing nutrient and sediment enrichment impairments are limited to different dissolved oxygen concentrations, which apply separately to each jurisdiction's tidal waters.

Table IV-1. Summary of current designated uses for states' Chesapeake Bay and tidal tributary waters.

State	Current Designated Use for Chesapeake Bay and Tidal Tributary Waters
Maryland	• Use II (shellfish harvesting waters) n Chesapeake Bay proper • Use I (water contact recreation, protection of aquatic life) n All surface waters
Virginia	• Class II (estuarine waters) for tidal water n Coastal zone to fall line n Primary and secondary contact recreation, fish and shellfish consumption, aquatic life and wildlife "All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish."
Delaware	• Chesapeake Drainage System, Choptank River, Marshyhope Creek n Industrial water supply, primary contact recreation, secondary contact recreation, fish and aquatic life and wildlife, agriculture water supply • Broad Creek, Nanticoke River n Same designated uses as above with the exception that these basins are also classified as "waters of exceptional recreational and ecological significance" (ERES waters)
District of Columbia	• Potomac River Class A (primary contact recreation), B (primary contact recreation and aesthetics), C (protection and propagation of fish, shellfish, and wildlife), D (consumption of fish and shellfish) and E (navigation)

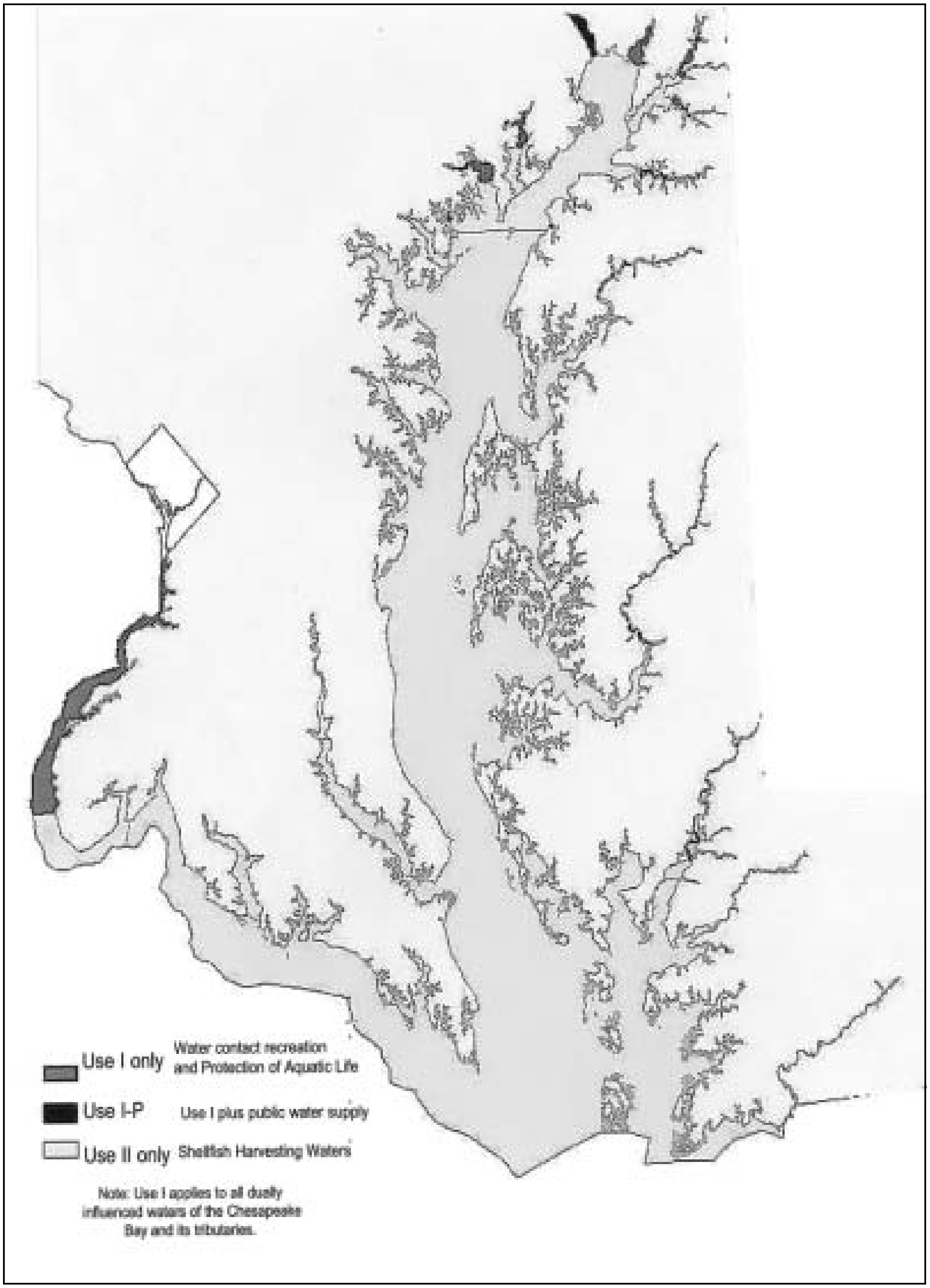

Figure IV-1. Current designated uses for Chesapeake Bay and tidal tributary waters located in Maryland.

Source: Code of Maryland Regulations 26.08.02 for water quality dated November 1, 1993.

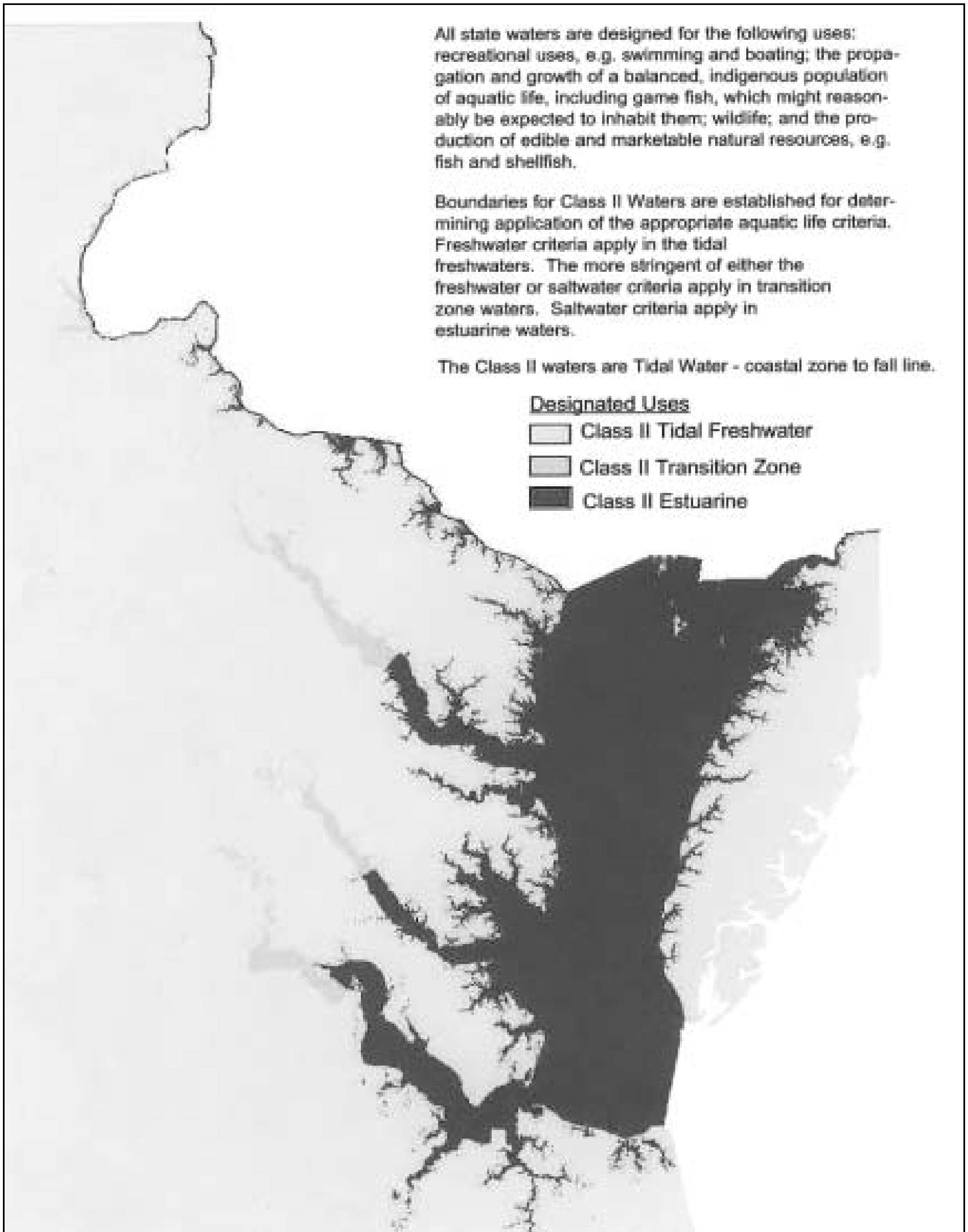

Figure IV-2. Current designated uses for Chesapeake Bay and tidal tributary waters located in Virginia.

Source: Virginia State Water Control Board Regulation 9 VAC 25-260-5-et. seq. Water Quality Standards dated December 10, 1997.

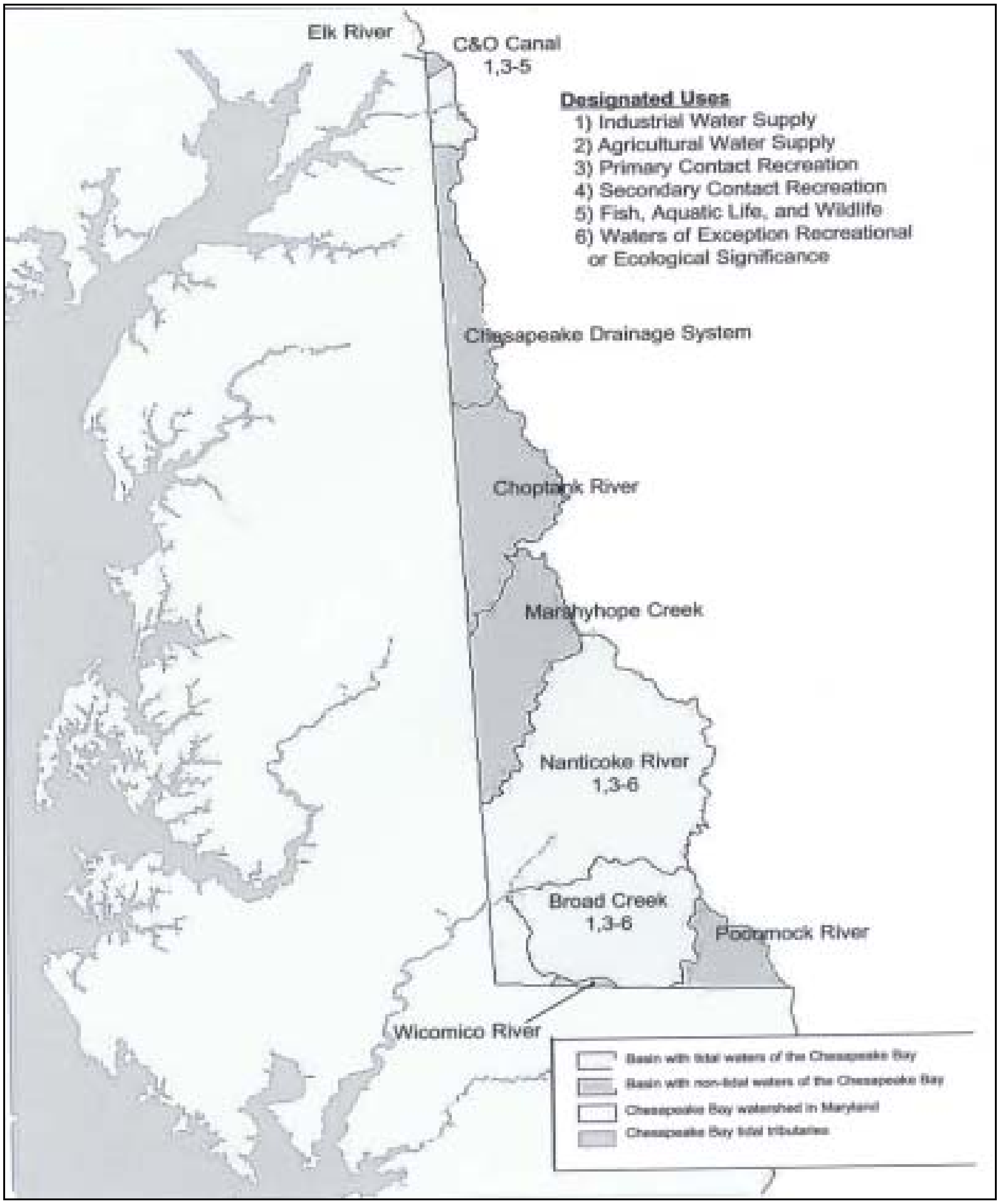

Figure IV-3. Current designated uses for Chesapeake Bay tidal tributary waters located in Delaware.

Source: Code of Delaware Water Quality Regulations.

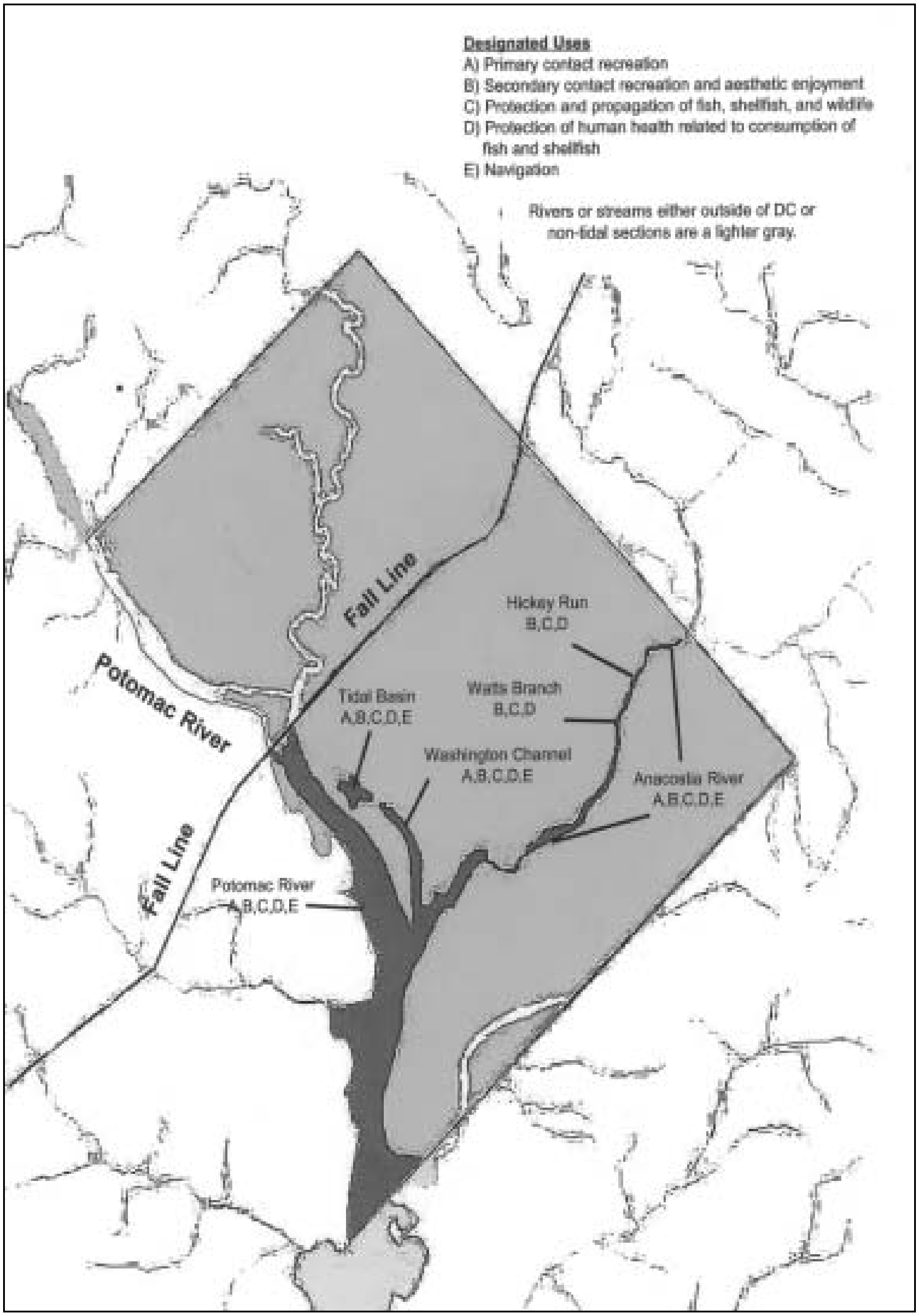

Figure IV-4. Current designated uses for Chesapeake Bay tidal tributary waters located in the District of Columbia.

Source: District of Columbia Department of Consumer and Regulatory Affairs Notice of Final Rulemaking.

REFINING TIDAL-WATER DESIGNATED USES

The Chesapeake Bay Program watershed partners determined that the underlying tidal-water designated uses must be refined to better reflect the desired and attainable Chesapeake Bay water quality conditions called for in the *Chesapeake 2000* agreement. In refining the current tidal-water designated uses, the six Chesapeake Bay watershed states and the District of Columbia took into account five principal considerations:

- Habitats used in common by sets of species and during particular life stages should be delineated as separate designated uses;

- Natural variations in water quality should be accounted for by the designated uses;

- Seasonal uses of different habitats should be factored into the designated uses;

- The Chesapeake Bay criteria for dissolved oxygen, water clarity and chlorophyll *a* should be tailored to support each designated use; and

- The refined designated uses applied to the Chesapeake Bay and its tidal tributary waters will support the federal Clean Water Act goals and state goals for uses existing in these water since 1975.

The Chesapeake Bay watershed partners are proposing five *refined subcategories* of the current broad aquatic life designated uses contained in the existing state water quality standards of the four jurisdictions bordering directly on Chesapeake Bay and its tidal tributaries. Figure IV-5 illustrates the conceptual framework of the refined tidal-water designated uses; Table IV-2 provides general descriptions of the five designated uses and the aquatic communities they were established to protect.[8] Four of the refined designated uses were derived largely to address seasonally distinct habitats and living resource communities with widely varying dissolved oxygen requirements:

- Migratory fish spawning and nursery;

- Open-water fish and shellfish;

- Deep-water seasonal fish and shellfish; and

- Deep-channel seasonal refuge.

The fifth refined designated use, the shallow-water bay grass designated use, occurs seasonally in conjunction with that part of the year-round open-water use which borders the land along the

[8] Note that for brevity, these refined designated uses may be referred to as migratory spawning and nursery, shallow-water, open-water, deep-water and deep-channel.

tidal portions of the Chesapeake Bay and its tributaries (Figure IV-5).

Table IV-2. General descriptions of the five proposed Chesapeake Bay tidal-water designated uses.

Migratory Fish Spawning and Nursery Designated Use: Aims to protect migratory finfish during the late winter/spring spawning and nursery season in tidal freshwater to low-salinity habitats. This habitat zone is primarily found in the upper reaches of many Bay tidal rivers and creeks and the upper mainstem Chesapeake Bay and will benefit several species, including striped bass, perch, shad, herring and sturgeon.
Shallow-Water Designated Use: Designed to protect underwater bay grasses and the many fish and crab species that depend on the shallow-water habitat provided by underwater bay grass beds.
Open-Water Fish and Shellfish Designated Use: Aims to improve water quality in the surface water habitats within tidal creeks, rivers, embayments and the mainstem Chesapeake Bay year-round. This use protects diverse populations of sport fish including striped bass, bluefish, mackerel and sea trout, bait fish such as menhaden and silversides, as well as the listed shortnose sturgeon.
Deep-Water Seasonal Fish and Shellfish Designated Use: Aims to protect living resources inhabiting the deeper transitional water column and bottom habitats between the well-mixed surface waters and the very deep channels during the summer months. This use protects many bottom-feeding fish, crabs and oysters, as well as other important species, including the bay anchovy.
Deep-Channel Seasonal Refuge Designated Use: Designed to protect bottom sediment-dwelling worms and small clams that act as food for bottom-feeding fish and crabs in the very deep channel in summer. The deep-channel designated use recognizes that low dissolved oxygen conditions prevail in the deepest portions of this habitat zone and will naturally have very low to no oxygen during the summer.

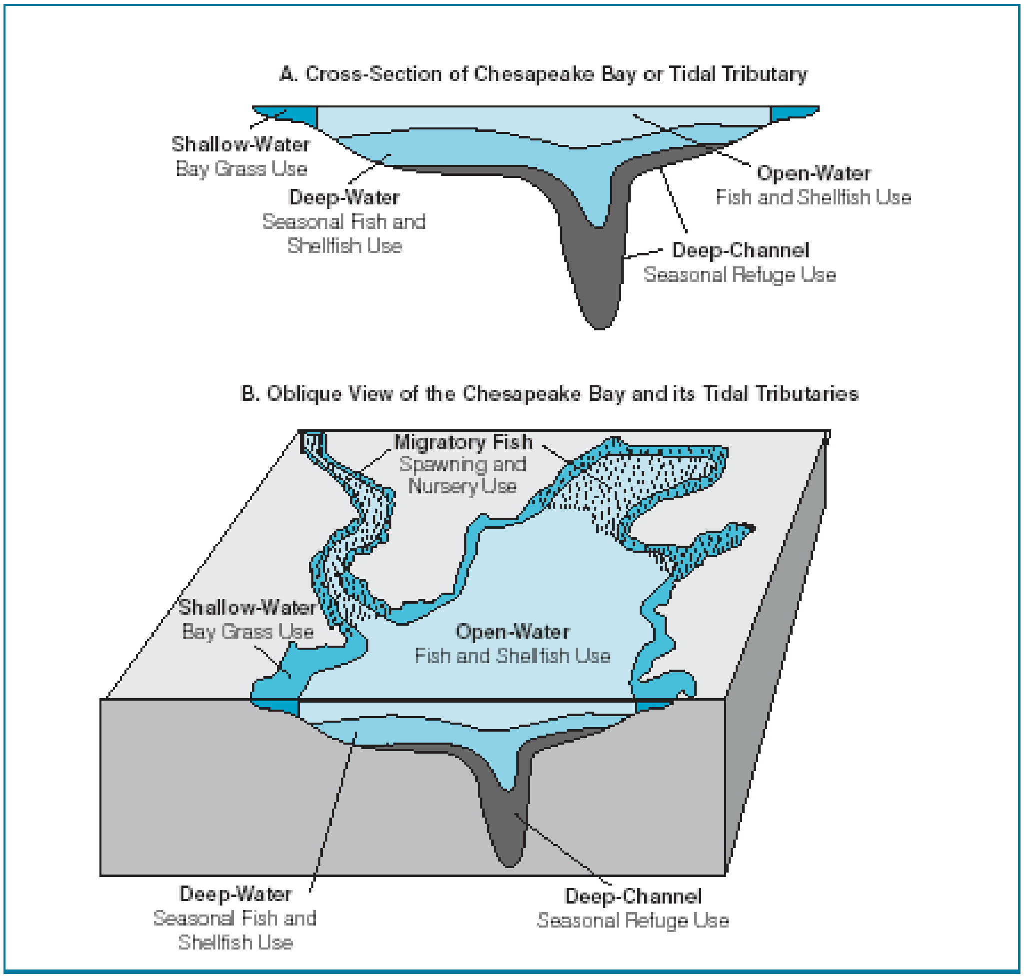

Figure IV-5. Conceptual illustration of the five Chesapeake Bay tidal-water designated use zones.

Living Resource-Based Refined Designated Uses and Protective Criteria

The five refined designated uses were derived to reflect the habitats of an array of recreationally, commercially and ecologically important species. The supporting prey communities were given full consideration along with the 'target species' in defining the designated uses.

Two extensive syntheses of habitat requirements for important target species and communities in the Chesapeake Bay and its tidal tributaries formed the basis from which these refined designated uses were conceived and developed (Chesapeake Bay Living Resource Task Force 1987; Funderburk et al. 1991). Only when coupled with analyses of the extensive Chesapeake Bay Monitoring Program's water quality, biological and living resource databases, now spanning 19 years, could the refined tidal-water designated uses described below be documented and delineated across all tidal-water habitats without constraints by jurisdictional borders.

The five tidal-water designated uses, in turn, provided the context for deriving dissolved oxygen, water clarity and chlorophyll *a* water quality criteria for the Chesapeake Bay and its tidal tributaries. These criteria, derived to protect each of the five refined designated uses, were based on effects data from a wide array of biological communities to capture the range of sensitivity of the thousands of aquatic species inhabiting the Chesapeake Bay and tidal tributary estuarine habitats (U.S. EPA 2003). Table IV-3 shows the proposed refined designated uses by Chesapeake Bay Program segment.

Table IV-3. Recommended tidal-water designated uses by Chesapeake Bay Program segment.

Chesapeake Bay Program (CBP) Segment Name	CBP Segment	Migratory Spawning and Nursery (Feb. 1 - May 31)	Open - Water (Year-Round)	Deep-Water (June 1 - Sept. 30)	Deep-Channel (June 1 - Sept. 30)	Shal-low-Water (April 1 -Oct. 30)
Northern Chesapeake Bay	CB1TF	x	x			x
Upper Chesapeake Bay	CB2OH	x	x			x
Upper Central Chesapeake Bay	CB3MH	x	x	x	x	x
Middle Central Chesapeake Bay	CB4MH		x	x	x	x
Lower Central Chesapeake Bay	CB5MH		x	x	x	x
Western Lower Chesapeake Bay	CB6PH		x	x		x
Eastern Lower Chesapeake Bay	CB7PH		x	x		x
Mouth of the Chesapeake Bay	CB8PH		x			x
Bush River	BSHOH	x	x			x
Gunpowder River	GUNOH	x	x			x
Middle River	MIDOH	x	x			x
Back River	BACOH	x	x			x
Patapsco River	PATMH	x	x	x		x
Magothy River	MAGMH	x	x			x
Severn River	SEVMH	x	x			x
South River	SOUMH	x	x			x
Rhode River	RHDMH	x	x			x
West River	WSTMH	x	x			x
Upper Patuxent River	PAXTF	x	x			x
Western Branch (Patuxent River)	WBRTF	x	x			x
Middle Patuxent River	PAXOH	x	x			x
Lower Patuxent River	PAXMH	x	x	x		x
Upper Potomac River	POTTF	x	x			x
Anacostia River	ANATF	x	x			x
Piscataway Creek	PISTF	x	x			x
Mattawoman Creek	MATTF	x	x			x
Middle Potomac River	POTOH	x	x			x
Lower Potomac River	POTMH	x	x	x	x	x
Upper Rappahannock River	RPPTF	x	x			x
Middle Rappahannock River	RPPOH	x	x			x

Chesapeake Bay Program (CBP) Segment Name	CBP Segment	Migratory Spawning and Nursery (Feb. 1 - May 31)	Open - Water (Year-Round)	Deep-Water (June 1 - Sept. 30)	Deep-Channel (June 1 - Sept. 30)	Shal-low-Water (April 1 -Oct. 30)
Lower Rappahannock River	RPPMH	x	x	x	x	x
Corrotoman River	CRRMH	x	x			x
Piankatank River	PIAMH	x	x			x
Upper Mattaponi River	MPNTF	x	x			x
Lower Mattaponi River	MPNOH	x	x			x
Upper Pamunkey River	PMKTF	x	x			x
Lower Pamunkey River	PMKOH	x	x			x
Middle York River	YRKMH	x	x			x
Lower York River	YRKPH		x	x		x
Mobjack Bay	MOBPH		x	x		x
Upper James River	JMSTF	x	x			x
Appomattox River	APPTF	x	x			x
Middle James River	JMSOH	x	x			x
Chickahominy River	CHKOH	x	x			x
Lower James River	JMSMH	x	x			x
Mouth of the James River	JMSPH		x			x
Western Branch Elizabeth River	WBEMH		x			
Southern Branch Elizabeth River	SBEMH		x			
Eastern Branch Elizabeth River	EBEMH		x			
Mouth to mid-Elizabeth River	ELIMH		x			
Lafayette River	LAFMH		x			
Mouth of the Elizabeth River	ELIPH		x	x	x	
Lynnhaven River	LYNPH		x			x
Northeast River	NORTF	x	x			x
C&D Canal	C&DOH	x	x			x
Bohemia River	BOHOH	x	x			x
Elk River	ELKOH	x	x			x
Sassafras River	SASOH	x	x			x
Upper Chester River	CHSTF	x	x			x
Middle Chester River	CHSOH	x	x			x
Lower Chester River	CHSMH	x	x	x	x	x
Eastern Bay	EASMH		x	x	x	x
Upper Choptank River	CHOTF	x	x			
Middle Choptank River	CHOOH	x	x			x

Chesapeake Bay Program (CBP) Segment Name	CBP Segment	Migratory Spawning and Nursery (Feb. 1 - May 31)	Open - Water (Year-Round)	Deep-Water (June 1 - Sept. 30)	Deep-Channel (June 1 - Sept. 30)	Shal-low-Water (April 1 -Oct. 30)
Lower Choptank River	CHOMH2	x	x			x
Mouth of the Choptank River	CHOMH1	x	x			x
Little Choptank River	LCHMH		x			x
Honga River	HNGMH		x			x
Fishing Bay	FSBMH	x	x			x
Upper Nanticoke River	NANTF	x	x			x
Middle Nanticoke River	NANOH	x	x			x
Lower Nanticoke River	NANMH		x			x
Wicomico River	WICMH	x	x			x
Manokin River	MANMH	x	x			x
Big Annemessex River	BIGMH	x	x			x
Upper Pocomoke River	POCTF	x	x			
Middle Pocomoke River	POCOH	x	x			x
Lower Pocomoke River	POCMH		x			x
Tangier Sound	TANMH		x			x

CHESAPEAKE BAY TIDAL-WATER DESIGNATED USES

The migratory fish spawning and nursery designated use is described first, given its unique seasonal role in protecting the spawning and nursery grounds of Chesapeake Bay and East Coast anadromous fish species. The shallow-water bay grass designated use is then described, as it protects the vegetated shallow-water habitats that are so critical to many individual estuarine species and living resource communities. Next, the open-water, deep-water and deep-channel designated uses are described as a series of year-round and seasonal subcategory designated uses formed around unique habitats defined largely by natural conditions (e.g., stratification of the water column, water circulation patterns) and physical barriers (Bay and tidal-water bottom bathymetry) in the tidal waters.

The watershed states with tidally influenced Chesapeake Bay waters (Maryland, Virginia and Delaware) and the District of Columbia ultimately are responsible for defining and adopting the designated uses into their state water quality standards. These uses will be adopted as subcategories of current state tidal-water designated uses, which are designed to protect aquatic life. The formal process for refining designated uses will meet the requirements of the Clean Water Act and any applicable jurisdiction-specific environmental laws or regulations.

The adopted designated uses will protect existing aquatic and human uses of the tidal waters that have been present since 1975. These designations go beyond minimum requirements (131.10[d] and [h][2]) and satisfy all requirements for meeting Clean Water Act goals (131.10 [a]), downstream waters maintenance and protection (131.10[b]) and for subcategorization as allowed by 131.10(g). The specific use definitions and the spatial application of the final designated uses will undergo public review through the four jurisdictions' respective regulatory adoption processes prior to EPA approval of the states' water quality standards.

Migratory Fish Spawning and Nursery Designated Use

Waters with this designated use shall support the survival, growth and propagation of balanced indigenous populations of ecologically, recreationally and commercially important anadromous, semi-anadromous and tidal freshwater resident fish species inhabiting spawning and nursery grounds from February 1 through May 31 (Table IV-4).

Table IV-4. Migratory fish spawning and nursery designated use summary.

Applicable Criteria:	Dissolved Oxygen: 6.0 mg/l 7-day mean (only tidal habitats with 0–0.5 ppt salinity) 5.0 mg/l instantaneous minimum
Application:	February 1 through May 31
Designated Use:	This designated use supports the survival, growth and propagation of balanced, indigenous populations of ecologically, recreationally and commercially important anadromous, semi-anadromous and tidal freshwater resident fish species inhabiting spawning and nursery grounds.
Designated Use Boundary:	The boundaries of this use extend from tidally influenced waters upriver, down to the upper Chesapeake Bay end of spawning and nursery habitats. The use extends horizontally from the shoreline of the body of water to the adjacent shoreline, and extends down through the water column to the bottom sediment-water interface.

Designated Use Rationale

Based on the *1987 Chesapeake Bay Agreement* (Chesapeake Executive Council 1987), a list of target anadromous and semi-anadromous species was identified, including striped bass, American shad, hickory shad, alewife, blueback herring, white perch and yellow perch, based on their commercial, recreational and ecological value and “the threat to sustained production due to population decline or serious habitat degradation” (Chesapeake Bay Living Resources Task Force 1987). These species form a representative subset of species comprising a “balanced, indigenous population.” Other ecologically important anadromous and semi-anadromous fish species also will be protected under this designated use.

Chesapeake Bay tidal waters support spawning and nursery areas that are important not only to Bay fishery populations, but also to populations that inhabit the entire East Coast, such as striped bass. The eggs, larvae and early juveniles of anadromous and semi-anadromous species often have more sensitive habitat quality requirements than other species and life stages (Funderburk et al. 1991; Jordan et al. 1992). These same habitats are critical spawning and nursery grounds for tidal freshwater resident fish species from February 1 to May 31 (U.S. EPA 2003). Thus, the combined migratory and tidal freshwater resident fish spawning and nursery habitats were delineated as a refined tidal-water designated use for the Chesapeake Bay and its tidal tributaries.

Designated Use Boundary Delineation

The boundaries of the migratory fish spawning and nursery designated use were delineated from the upriver extent of tidally influenced waters to the downriver and upper Chesapeake Bay end of spawning and nursery habitats that have been determined through a composite of all targeted anadromous and semi-anadromous fish species’ spawning and nursery habitats (Figure IV-6).

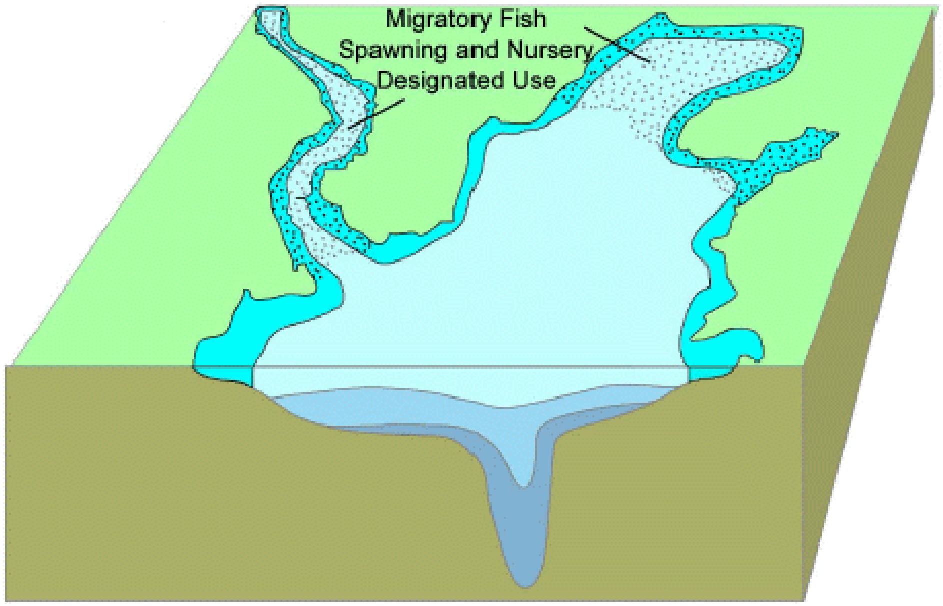

Figure IV-6. Illustration of the boundaries of the migratory fish spawning and nursery designated use (stippled area).

Critical Support Communities—Food and Shelter

In this designated use, spawning adults and the resulting larvae and early juvenile fish depend on phytoplankton, zooplankton, bottom-dwelling worms and clams and forage fish as prey (Funderburk et al. 1991). The presence of underwater bay grasses in the shallows of the designated use habitat provides essential shelter for young juveniles as well as many prey species.

Seasonal Use Application

The migratory fish spawning and nursery designated use applies from February 1 through May 31. The defined season for applying this use is based on a composite of the full range of spawning and nursery periods of all the target anadromous and semi-anadromous species.

Striped bass and juveniles of other migratory spawners are passively dispersed as eggs and larvae and move farther downstream as they grow. Most juveniles do not leave the boundaries of their respective spawning and nursery areas. Adult yellow perch migrate from downstream to their spawning areas in the lower-salinity upper reaches of the tidal tributaries from mid-February through March (Richkus and Stroup 1987; Tsai and Gibson 1971). By early June, young-of-the-year juvenile striped bass begin to move shoreward, spending the summer and early fall in shoal waters less than six feet deep (Setzler-Hamilton et al. 1981). As juveniles grow, they move progressively downriver (Boreman and Klauda 1988; Dey 1981; Setzler-Hamilton et al. 1981). The February 1 beginning date reflects the initiation of the yellow perch spawning season; the May 31 end date reflects when the eggs and larvae have finished their transition to the juvenile life stage for all the target anadromous and semi-anadromous species.

Applicable Chesapeake Bay Water Quality Criteria[9]

The migratory fish spawning and nursery designated use is seasonally defined and occurs in conjunction with the year-round open-water designated uses and the seasonal shallow-water designated uses (see Figure IV-5). The migratory fish spawning and nursery designated use provides for the protection of the early life stages of anadromous, semi-anadromous and resident tidal-fresh species through the application of dissolved oxygen criteria derived for that purpose (U.S. EPA 2003). From February 1 through May 31, the migratory fish spawning and nursery dissolved oxygen criteria ensure protection of the egg, larval and early juvenile life stages (Table IV-4). Free-flowing streams and rivers, where several of the target species (e.g., shad, river herring) migrate for spawning, are protected through other existing state water quality standards.

The open-water fish and shellfish designated use dissolved oxygen criteria were derived to be protective of juvenile and adult life stages of anadromous and semi-anadromous species after May 31 (see Table IV-6; U.S. EPA 2003). The overlapping nature of these discrete designated uses will thus ensure that water quality conditions protective of different species' life stages are present in those designated use habitats. See chapters 3 and 6, respectively, in U.S. EPA 2003 for more details on the individual dissolved oxygen criteria and criteria implementation procedures.

Shallow-Water Bay Grass Designated Use

Waters with this designated use support the survival, growth and propagation of rooted, underwater bay grasses necessary for the propagation and growth of balanced, indigenous populations of ecologically, recreationally and commercially important fish and shellfish inhabiting vegetated shallow-water habitats (Table IV-5).

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[9] Maryland, Virginia, Delaware and the District of Columbia currently have water quality standards in place that address pH conditions within the migratory fish spawning and nursery habitats.

Table IV-5. Shallow-water bay grass designated use summary.

Applicable Criteria:	Water Clarity: 13 percent ambient light through water (tidal habitats with 0–5 ppt salinity) 22 percent ambient light through water (tidal habitats with greater than 5 ppt salinity)
Application:	April 1 through October 31 for tidal-fresh, oligohaline and mesohaline habitats (0–18 ppt salinity) March 1 through May 31 and September 1 through November 30 for polyhaline habitats (>18 ppt salinity)
Designated Use:	Waters with this designated use support the survival, growth and propagation of rooted underwater bay grasses necessary for the propagation and growth of balanced, indigenous populations of ecologically, recreationally and commercially important fish and shellfish inhabiting vegetated shallow-water habitats.
Designated Use Boundary:	Tidally influenced waters from the intertidal zone out to a Chesapeake Bay Program segment-specific depth contour that varies from 0.5 to 2 meters.

Designated Use Rationale

The shallow-water bay grass designated use protects a wide variety of species, such as largemouth bass and pickerel, which inhabit vegetated tidal-fresh and low-salinity habitats; juvenile speckled sea trout in vegetated higher salinity areas; and blue crabs that inhabit vegetated shallow-water habitats covering the full range of salinities encountered in the Chesapeake Bay and its tidal tributaries. Underwater bay grasses, the critical community that the designated use protects, provide the shelter and food that make shallow-water habitats so unique and integral to the productivity of the Chesapeake Bay ecosystem. Many Chesapeake Bay species depend on vegetated shallow-water habitats at some point during their life cycle (Funderburk et al. 1991). Given the unique nature of this habitat and its critical importance to the Chesapeake Bay ecosystem, shallow waters were delineated as a refined tidal-water designated use for the Chesapeake Bay and its tidal tributaries.

The shallow-water bay grass designated use is intended specifically to delineate the habitats where the water clarity criteria would apply. The open-water fish and shellfish designated use and the accompanying dissolved oxygen criteria will fully protect the biological communities inhabiting shallow-water habitats. The open-water designated use extends into the intertidal zone and protects shallow-water organisms beyond underwater bay grasses. The seasonal shallow-water bay grass designated use, similar to the migratory fish spawning and nursery use, actually occurs in conjunction with the year-round open-water designated use (see Figure IV-5) and provides specific protection for underwater bay grasses through the application of water clarity criteria.

Designated Use Boundary Delineation

The shallow-water bay grass designated use covers tidally influenced waters, from the intertidal zone out to a Chesapeake Bay Program segment-specific depth contour that varies from 0.5 to 2 meters (Figure IV-7). The segment-specific depths were based on rules described in detail in "Shallow-Water Bay Grass Designated Use Boundaries" (see page125) along with two other approaches to defining shallow-water use boundaries.

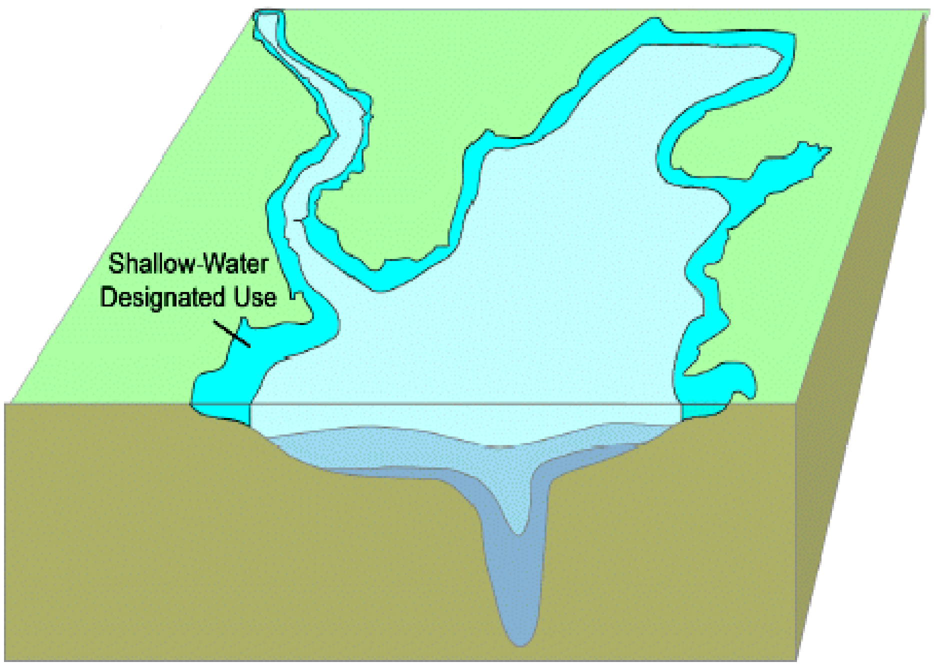

Figure IV-7. Illustration of the boundaries of the shallow-water bay grasses designated use.

Critical Support Communities—Food and Shelter

Phytoplankton, zooplankton, forage fish and bottom-dwelling worms and clams feed many fish, crab and mollusk species that inhabit shallow-water habitats for part or all of their life stages (Funderburk et al. 1991). Water quality criteria necessary to fully support the shallow-water designated use must provide for the survival, growth and successful propagation of prey communities in sufficient quantities.

Applicable Bay Water Quality Criteria

The shallow-water bay grass designated use is a seasonal use designation that occurs in conjunction with the year-round open-water use and the seasonal migratory spawning and nursery designated uses (see Figure IV-5). The shallow-water bay grass designated use boundary delineates where specific levels of water clarity must be restored to support restoration of underwater bay grasses. The applicable salinity regime-based water clarity criteria apply during the appropriate underwater bay grass growing season: April 1 through October 31 for tidal-fresh, oligohaline and mesohaline habitats and March 1 through May 31 and September 1 through November 30 for polyhaline habitats (see Table IV-5; U.S. EPA 2003).

Underlying the seasonal shallow-water bay grass designated use is the year-round open-water fish and shellfish designated use to support grass living resource communities inhabiting these shallow-water areas (see Table IV-6; U.S. EPA 2003). The open-water fish and shellfish dissolved oxygen criteria apply into the shallows to the intertidal zone. Therefore, nonvegetated shallow-water habitats and the living resource communities that depend on those habitats will receive protection under the open-water designated use. See chapters 3, 4 and 6, respectively, in U.S. EPA 2003 for more details on the individual dissolved oxygen criteria, water clarity criteria and criteria implementation guidelines.

Open-Water Fish and Shellfish Designated Use

Waters with this designated use support the survival, growth and propagation of balanced, indigenous populations of ecologically, recreationally and commercially important fish and shellfish species inhabiting open-water habitats (Table IV-6).

Table IV-6. Open-water fish and shellfish designated use summary.

Applicable Criteria:	Dissolved Oxygen: 5.5 mg/l 30-day mean (tidal habitats with 0–0.5 ppt salinity) 5.0 mg/l 30-day mean (tidal habitats with greater than 0.5 ppt salinity) 4.0 mg/l 7-day mean 3.2 mg/l instantaneous minimum Chlorophyll *a*: Concentrations of chlorophyll *a* in free-floating microscopic aquatic plants (algae) shall not exceed levels that result in ecologically undesirable consequences–such as reduced water clarity, low dissolved oxygen, food supply imbalances, proliferation of species deemed potentially harmful to aquatic life or humans or aesthetically objectionable conditions–or otherwise render tidal waters unsuitable for designated uses.
Application:	Year-round: open-water designated use and dissolved oxygen criteria March 1 through May 31 and July 1 through September 30: chlorophyll *a* criteria.
Designated Use:	Waters with this designated use support the survival, growth and propagation of balanced, indigenous populations of ecologically, recreationally and commercially important fish and shellfish species inhabiting open-water habitats.
Designated Use Boundary:	From June 1 through September 30 the open-water designated use includes tidally influenced waters extending horizontally from the shoreline to the adjacent shoreline. If a pycnocline is present and, in combination with bottom bathymetry and water-column circulation patterns, presents a barrier to oxygen replenishment of deeper waters, the open-water fish and shellfish designated use extends down into the water column only as far as the measured upper boundary of the pycnocline. If a pycnocline is present but other physical circulation patterns (such as influx of oxygen rich oceanic bottom waters) provide for oxygen replenishment of deeper waters, the open-water fish and shellfish designated use extends down into the water column to the bottom water-sediment interface. From October 1 through May 31, the open-water designated use includes all tidally influenced waters extending horizontally from the shoreline to the adjacent shoreline, extending down through the water column to the bottom water-sediment interface.

Designated Use Rationale

The natural temperature and salinity stratification of open waters influences dissolved oxygen concentrations and, thus, the distribution of Chesapeake Bay species. Surface mixed-layer waters with higher oxygen levels located above the pycnocline support a different community of species than deeper waters from late spring to early fall. Several well-known species that inhabit these open waters are menhaden, striped bass and bluefish. Their habitat requirements and prey needs differ from those of species and communities inhabiting deeper water habitats during the summer months. See the deep-water “Designated Uses Rationale” on page 87 for more detailed documentation.

Clear evidence from the Chesapeake Bay as well as other estuarine and coastal systems, including Long Island Sound (Howell and Simpson 1994), Albemarle-Pamlico Sound (Eby 2001) and the Gulf of Mexico (Craig et al. 2001), indicates that the fish and other organisms inhabiting open-water habitats will use deeper within-pycnocline and below-pycnocline habitats, given suitable dissolved oxygen conditions. It is the lack of sufficient oxygen, not the presence of stratification, that limits the use of these deeper habitats. Therefore, the open-water designated use applies to transitional pycnocline and bottom mixed-layer below-pycnocline habitats where these below-pycnocline and pycnocline waters are sufficiently reoxygenated by oceanic or riverine waters.

During their first winter of life, members of five important Chesapeake Bay species—white perch, striped bass, Atlantic croaker, shortnose sturgeon and Atlantic sturgeon—are constrained to oligohaline and mesohaline regions (< 20 ppt) in the upper Chesapeake Bay mainstem, and seek out warmer temperatures that occur in deeper channel waters below the thermocline. From October through May, the deep-channel habitats in the upper Bay adjacent to shallower summer and fall habitats should be considered important nursery habitats for young-of-the-year juvenile white perch, striped bass, and Atlantic croaker (Pothoven et al. 1997) as well as Atlantic and shortnose sturgeon (Miller et al. 1997; Secor et al. 2000; Welsh et al. 2000).

During the coldest months, the interaction between temperatures and salinity tolerances may result in a ‘habitat squeeze’ or bottleneck, forcing juveniles into deep-channel habitats seeking preferred temperatures. Unpublished data from the Maryland Environmental Service indicate that a thermocline, separating the warmer deep waters from colder overlaying waters, typically occurs at a 10-to 20-meter depth in the deep channel from October through February. Therefore, from fall through late spring when the open-water designated use applies to these natural channel habitats, it also protects indigenous populations of important fish species that depend on deep-channel habitats for overwintering.

Based on these natural conditions and their influence on oxygen levels and the seasonal distributions of Chesapeake Bay species, open waters were delineated as a refined tidal-water designated use in the Chesapeake Bay.

Designated Use Boundary Delineation

From June 1 through September 30 the open-water designated use includes tidally influenced waters extending horizontally from the shoreline to the adjacent shoreline (Figure IV-8). If a pycnocline is present and, in combination with bottom bathymetry and water-column circulation patterns, presents a barrier to oxygen replenishment of deeper waters, the open-water fish and shellfish designated use extends down into the water column only as far as the measured upper boundary of the pycnocline (Figure IV-9). If a pycnocline is present but other physical circulation patterns (such as influx of oxygen rich oceanic bottom waters) provide for oxygen replenishment of deeper waters, the open-water fish and shellfish designated use extends down through the water column to the bottom water-sediment interface.

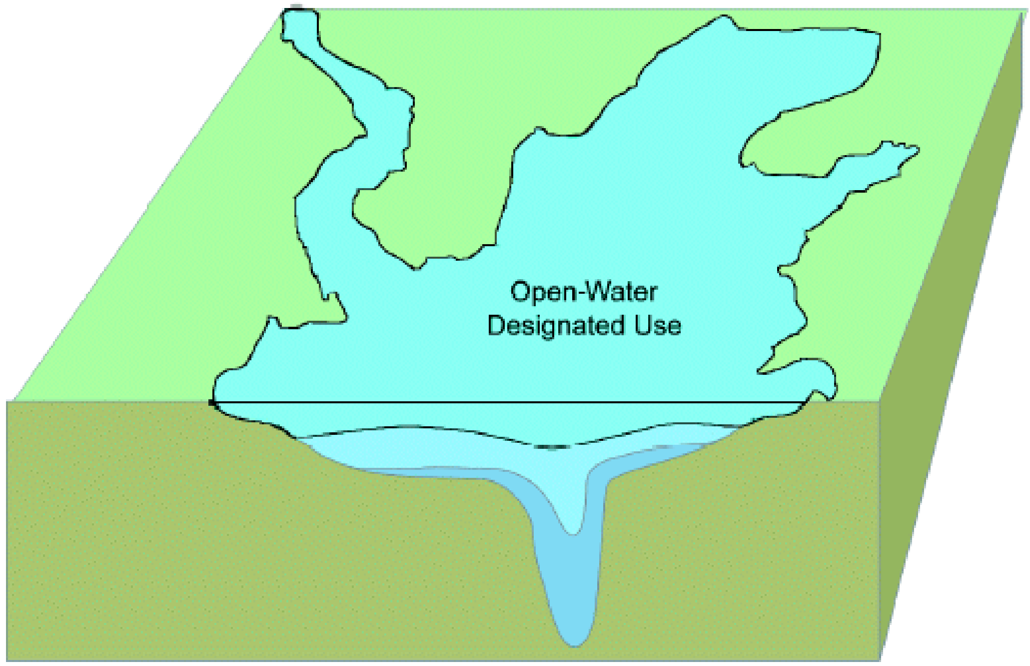

Figure IV-8. Illustration of the boundaries of the open-water fish and shellfish designated use.

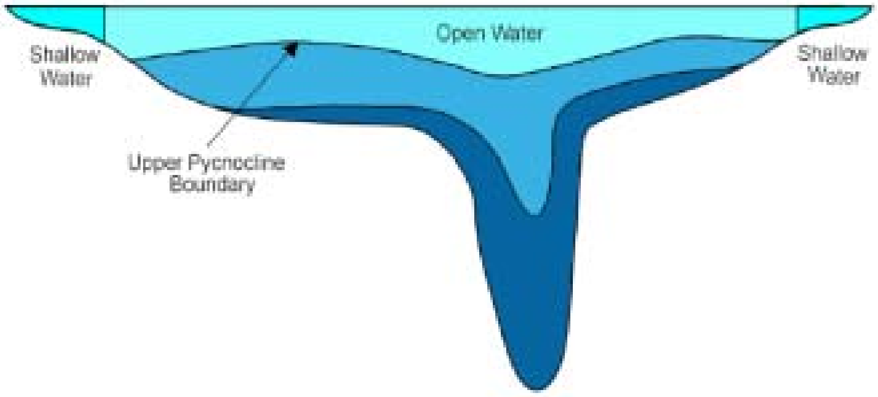

Figure IV-9. Illustration of the vertical boundaries for the refined open-water fish and shellfish designated use.

From October 1 through May 31, the boundaries of the open-water designated use includes all tidally influenced waters extending horizontally from the shoreline to the adjacent shoreline, extending down through the water column to the bottom water-sediment interface.

Critical Support Communities—Food and Shelter

Water column-dwelling phytoplankton, zooplankton and forage fish constitute the major prey for other species in the Chesapeake Bay's open waters (Funderburk et al. 1991). Water quality criteria to support the open-water designated use fully must provide for the survival, growth and successful propagation of quality prey communities in sufficient quantities.

Applicable Bay Water Quality Criteria

The open-water dissolved oxygen criteria apply year-round (see Table IV-6). The applicable salinity regime-based chlorophyll *a* criteria apply only in spring (March 1 through May 31) and summer (July 1 through September 30) to the open-water designated use habitats. See chapters 3 and 5, respectively, in U.S. EPA (2003) for more details on the individual dissolved oxygen and chlorophyll *a* criteria and chapter 6 for detailed criteria implementation procedures.

Deep-Water Seasonal Fish and Shellfish Designated Use

Waters with this designated use protect the survival, growth and propagation of balanced, indigenous populations of important fish and shellfish species inhabiting deep-water habitats (Table IV-7).

Table IV-7. Deep-water seasonal fish and shellfish designated use summary.

Applicable Criteria:	Dissolved Oxygen: 3 mg liter^{-1} 30-day mean 2.3 mg liter^{-1} 1-day mean 1.7 mg liter^{-1} instantaneous minimum
Application:	June 1 through September 30
Designated Use:	Waters with this designated use protect the survival, growth and propagation of balanced, indigenous populations of important fish and shellfish species inhabiting deep-water habitats.
Designated Use Boundary:	Tidally influenced waters located between the measured depths of the upper and lower boundaries of the pycnocline in areas where the measured pycnocline, in combination with bottom bathymetry and water circulation patterns, presents a barrier to oxygen replenishment of deeper waters. In some areas where a lower boundary of the pycnocline is not calculated, the deep-water designated use extends from the measured depth of the upper boundary of the pycnocline down through the water column to the bottom sediment-water interface.

Designated Use Rationale

In an eutrophic system such as the Chesapeake Bay, excess organic matter settles to the bottom, where it fuels microbial activity (e.g., Malone et al. 1986; Tuttle et al. 1987). With more fuel, more oxygen is consumed and, where replenishment with oxygen-saturated waters is restricted, the water becomes more severely oxygen-depleted. There is evidence that hypoxic and anoxic conditions existed in the deeper waters of the Chesapeake Bay prior to European settlement (Cooper and Brush 1991). These same data indicate that anthropogenic activity has increased the extent, frequency and severity of oxygen depletion in the Chesapeake Bay (Zimmerman and Canuel 2000; Hagy 2002).

Many parts of the Chesapeake Bay become, on a seasonal basis, vertically stratified because of depth-related density differences in the water column, caused primarily by variations in salinity and, to a lesser degree, temperature. Warmer, freshwater from the rivers floats on top of the cooler, denser saltwater at the bottom that enters the Bay from the ocean. The gravitational force of the downriver flow of freshwater causes a wedge of deeper, saltier water to move up the Bay and upriver. Vertically, at some point in the water column, a zone of maximum density difference is reached, which inhibits or prevents the exchange between water above and below it. This region is called the pycnocline. In the summer months, respiration by organisms living below the pycnocline can deplete concentrations of dissolved oxygen. Because waters in and below the pycnocline are isolated from well-mixed surface waters, dissolved oxygen concentrations can decrease until they are stressful or lethal to higher organisms.

The formation of the pycnocline is a natural process. In areas where stratification is common, the pycnocline generally forms at about the same depth range, but is subject to seasonal and annual variations in depth due to river flow, temperature and salinity patterns. It is generally shallower at the mouths of rivers and the Chesapeake Bay and deeper at the heads of rivers. The effect of the pycnocline also is not the same everywhere in the Chesapeake Bay and is influenced by local characteristics such as bathymetry, vertical and horizontal water circulation patterns, and proximity to the ocean and major river fall-lines. In some parts of the Bay and its tidal rivers, these factors create a more complex stratification pattern: a second pycnocline is formed lower in the water column, dividing it into three layers. If a region is contained by the pycnocline above and by bottom bathymetry laterally, it is even more isolated from oxygen-replenishing waters.

Bay anchovy is a target species whose egg and larval life stages are spent in pycnocline waters (Keister et al. 2000; Rilling and Houde 1999; MacGregor and Houde 1996). Blue crabs, oysters, softshell clams, hard clams, spot, croaker, flounder and catfish inhabit the near-bottom waters in the deep-water habitats (Funderburk et al. 1991). The oxygen requirements of these species differ from those of species inhabiting shallow-water, open-water and deep-channel habitats. Their feeding patterns and distribution of eggs and larvae are greatly influenced by natural features of the water column such as the pycnocline.

Deep waters were delineated as a refined tidal-water designated use for the Chesapeake Bay and its tidal tributaries based on the unique nature of the pycnocline region as an important living resource habitat and the transitional nature of its water quality conditions.

Designated Use Boundary Delineation

The deep-water designated use includes the tidally influenced waters between the measured upper and lower boundaries of the pycnocline where, in combination with bottom bathymetry and water circulation patterns, the pycnocline limits oxygen replenishment of deeper waters (Figure IV-10). In some areas where a lower boundary of the pycnocline is not calculated, the deep-water designated use extends from the measured depth of the upper boundary of the pycnocline down through the water column to the bottom sediment-water interface.

Critical Support Communities—Food and Shelter

Bottom-dwelling worms and clams and reef-dwelling forage fish are important food sources for the fish and crabs in deep-water habitats (Funderburk et al. 1991). Water quality criteria to support the deep-water designated use must provide for the survival, growth and successful propagation of quality prey communities in sufficient quantities.

Seasonal Use Application

The deep-water seasonal fish and shellfish designated use applies from June 1 through

September 30. By June, a combination of natural water-column stratification and increased biological oxygen consumption driven by higher water temperatures prevents the Chesapeake Bay's deep waters from retaining high concentrations of dissolved oxygen. These natural conditions generally persist into September. From October 1 through May 31 the open-water fish and shellfish designated use applies to these same waters.

Applicable Bay Water Quality Criteria

The deep-water dissolved oxygen criteria apply from June 1 through September 30 (see Table IV-7). See chapters 3 and 6, respectively, in U.S. EPA 2003 for more details on the deep-water dissolved oxygen criteria and criteria implementation procedures.

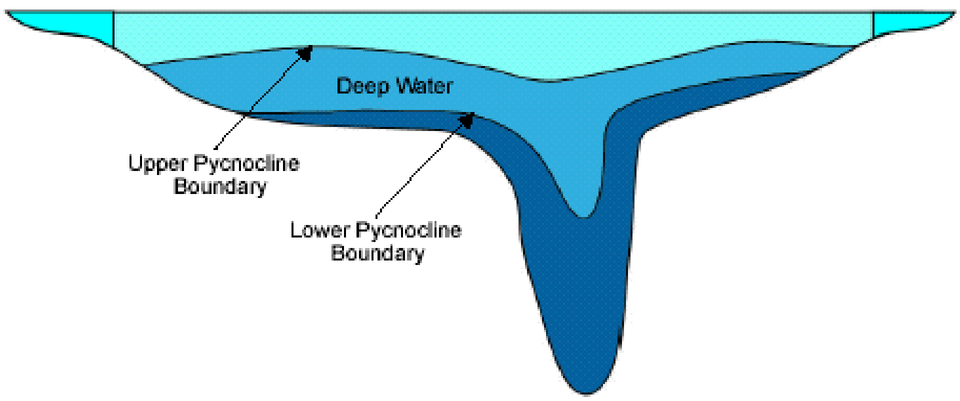

Figure IV-10. Illustration of the vertical boundaries for the refined deep-water seasonal fish and shellfish designated use.

Deep-Channel Seasonal Refuge Designated Use

Waters with this designated use must protect the survival of balanced, indigenous populations of ecologically important benthic infaunal and epifaunal worms and clams, which provide food for bottom-feeding fish and crabs (Table IV-8).

Table IV-8. Deep-channel seasonal refuge designated use summary.

Applicable Criteria:	Dissolved Oxygen: 1.0 mg/l instantaneous minimum
Application:	June 1 through September 30
Designated Use:	Waters with this designated use must protect the survival of balanced, indigenous populations of ecologically important benthic infaunal and epifaunal worms and clams, which provide food for bottom-feeding fish and crabs.
Designated Use Boundary:	Deep-channel designated use waters are defined as tidally influenced waters at depths greater than the measured lower boundary of the pycnocline in areas where, in combination with bottom bathymetry and water circulation patterns, the pycnocline presents a barrier to oxygen replenishment of deeper waters. The deep-channel designated use is defined laterally by bathymetry of the trough and vertically by the lower boundary of the pycnocline above, and below, at the bottom sediment-water interface.

Designated Use Rationale

In the Chesapeake Bay, researchers have determined the oxygen minimum to be in the below-pycnocline waters throughout the deep trough in the mainstem Chesapeake Bay in the late spring to early fall (Smith et al. 1992). Isolated from aerated surface waters, low dissolved oxygen concentrations in this region are due to excess oxygen consumption from bacterial breakdown of organic material over oxygen additions from ocean waters flowing in from far down-Bay. North of this region, the trough quickly becomes shallow and bottom waters are oxygenated as they mix with aerated waters in the shoals. Below-pycnocline waters to the south are reoxygenated through mixing with oxygenated oceanic waters entering the Chesapeake Bay mouth.

These deep channels are sinks for excess organic material which, in the process of decaying, increase oxygen consumption. They are isolated from surface and oceanic sources of oxygen replenishment. Vertical stratification and gravitational and horizontal circulation often cause severe, sudden oxygen depletion beginning just below the lower boundary of the pycnocline and extending to the bottom (Smith et al. 1992). Given the physical nature of the deep trough leading to naturally severe oxygen depletion during the summer, the deep-channel was delineated as a refined tidal-water designated use for Chesapeake Bay.

Designated Use Boundary Delineation

Deep-channel designated use waters are defined as tidally influenced waters at depths greater than the measured lower boundary of the pycnocline in areas where the pycnocline, in combination with bottom bathymetry and water circulation patterns, presents a barrier to oxygen replenishment of deeper waters (Figure IV-11). The deep-channel designated use is defined laterally by bathymetry of the trough and vertically by the lower boundary of the pycnocline above, and below, at the bottom sediment-water interface.

Critical Support Communities—Food and Shelter

Bottom-dwelling worms and clams are the principal food source of bottom-feeding fish and crabs in the deep-channel (Funderburk et al. 1991). Water quality criteria for the deep-channel designated use must provide for the survival of these prey communities.

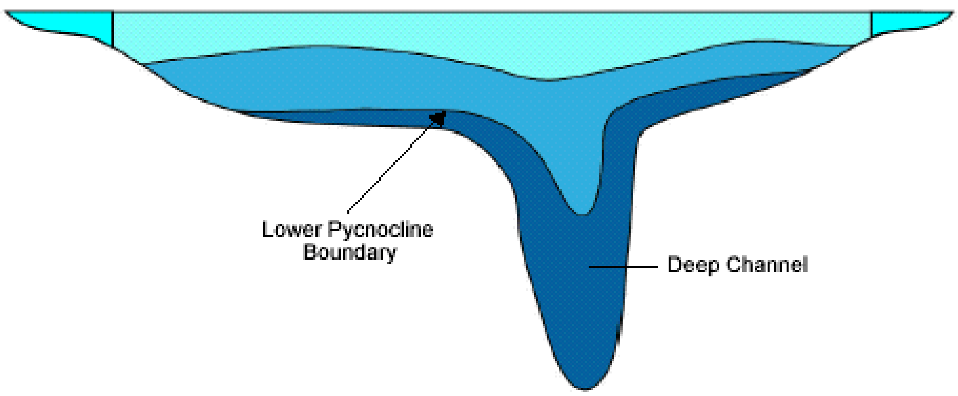

Figure IV-11. Illustration of the vertical boundaries of the refined deep-channel seasonal refuge designated use.

Seasonal Use Application

The deep-channel designated use applies from June 1 through September 30. By June, a combination of natural water-column stratification and increased water temperature prevents the Chesapeake Bay's deep-channel waters from retaining high concentrations of dissolved oxygen. These natural conditions generally persist through September. From October 1 through May 31 the open-water designated use applies to these same habitats.

Applicable Bay Water Quality Criteria

The deep-channel dissolved oxygen criteria apply from June 1 through September 30 (see Table IV-8). See chapters 3 and 6, respectively, in U.S. EPA 2003 for more details on the deep-channel dissolved oxygen criteria and criteria implementation procedures.

CHESAPEAKE BAY TIDAL-WATER DESIGNATED USE BOUNDARIES

Correct application of the Chesapeake Bay water quality criteria depends on the accurate delineation of the five tidal-water designated uses. Each of the designated uses has different dissolved oxygen criteria derived to match the respective level of protection required by different living resource communities. In case of the shallow-water bay grass designated use, the location of the boundaries is critical to providing sufficient suitable habitat for the restoration of the desired number of acres of underwater bay grasses.

The vertical depth and horizontal breadth of the designated use boundaries are based on a combination of factors: natural water-column stratification, bottom bathymetric features and circulation patterns, among other considerations. It is important to note that these boundaries have been developed without consideration of attainability from the perspective of potentially widespread social and economic impacts. The states may find they need to adjust these boundaries according to such impacts (131.19[g][6]), which may prevent attainment of the designated use, and must justify these adjustments during their water quality standards adoption processes. The technology-based attainability of these refined tidal-water designated uses and their boundaries is documented in Chapter V.

Four of the six factors defined in 40 CFR 101.10(g) justify deriving the boundaries described in this chapter for the refined tidal-water designated uses:

- Natural, ephemeral, intermittent or low-flow conditions or water levels (e.g., application of a 10-year water quality data record (1985-1994) reflecting a wide range of watershed hydrologic and tidal bay hydrodynamic conditions);

- Dams, diversion or other types of hydrologic modifications (e.g., dredged shipping channels);

- Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles and the like (e.g., water-column stratification, bottom bathymetry); and

- Naturally occurring pollutant concentrations (see Chapter III).

Migratory Fish Spawning and Nursery Designated Use Boundaries

The boundaries of the migratory fish spawning and nursery designated use were delineated from the upriver extent of tidally influenced waters to the downriver and upper Chesapeake Bay end of spawning and nursery habitats that have been determined through a composite of all targeted anadromous and semi-anadromous fish species' spawning and nursery habitats (Figure IV-12).

Free-flowing streams and rivers, where several of the target species (e.g., shad and river herring) migrate for spawning, are protected through other existing state water quality standards.

To generate these boundaries, habitat distribution maps, drawn from the *Habitat Requirements for Chesapeake Bay Living Resources–Second Edition* (Funderburk et al. 1991), were used. The distribution maps used during delineation of the migratory spawning and nursery designated use included:

- Alewife spawning and nursery;
- Alewife nursery;
- American shad spawning and nursery;
- American shad nursery;
- Hickory shad spawning and nursery;
- Herring spawning and nursery;
- Herring nursery;
- Striped bass spawning reaches;
- Striped bass spawning rivers;
- White perch nursery;
- White perch spawning; and
- Yellow perch spawning and nursery.

For those species that had multiple habitat distribution maps for related life stages, the maps were merged into a single coverage. Then individual species maps were superimposed on a composite spawning and nursery habitat map.

The striped bass habitat distribution maps used in this process were originally titled “Striped Bass Chesapeake Bay Spawning Reaches and Spawning Rivers” by Funderburk et al. (1991). The sources of the spawning reach distributions were research and monitoring findings synthesized by Setzler-Hamilton and Hall (1991). However, the mapped extent of the nursery areas, referred to as spawning rivers in the original map, was based on Maryland and Virginia legislative definitions,[10] not on fisheries survey findings.

[10] Code of Maryland Regulations 08.02.05.02 and Virginia Marine Resources Commission Regulation 450-01-0034 as cited in Chesapeake Bay Living Resources Task Force (1987).

Figure IV-12. Map showing the migratory spawning and nursery designated use for the Chesapeake Bay and its tidal tributaries (black areas).

Those regulations, which define “spawning rivers and areas,” did not attempt to define “early juvenile nursery habitat” but rather those rivers in which striped bass spawn. The spawning reach designation in the regulation was used to describe areas where striped bass eggs and larvae had been found. This justification was based on icthyoplankton collections done in the 1950s in Maryland (Mansueti and Hollis 1963). Tresselt (1952) defined spawning reaches in Virginia.

To further enhance understanding of nursery areas, discussions were held with fishery scientists Herb Austin and Deane Este of the College of William and Mary’s Virginia Institute of Marine Science, and Eric Durell, Maryland Department of Natural Resources, who are responsible for their respective states’ juvenile striped bass seine surveys. The primary nursery areas for young-of-the-year striped bass were delineated based on a comparison of long-term Maryland and Virginia seine survey data with the legislatively-defined extent of early juvenile nursery habitat. In any given year, juvenile striped bass can be found throughout a broader range of Chesapeake Bay tidal waters. The primary nursery areas where the highest concentrations of *early* juvenile life-stage striped bass are almost always found in the spring were identified and incorporated into the composite map described above (e.g., Austin et al. 2000). The striped bass nursery areas were supplemented to ensure that shad and river herring spawning and nursery areas were fully represented within the migratory fish spawning and nursery designated use boundaries (Rulifson 1994; Olney 2002).

From February 1 through May 31, the migratory fish spawning and nursery designated use occurs in conjunction with, and, therefore, encompasses specific portions of the seasonal shallow-water bay grass and year-round open-water fish and shellfish designated use habitats (see shaded sections in Figure IV-5). The designated use extends horizontally from the shoreline across the body of water to the adjacent shoreline, and extends down through the water column to the bottom sediment-water interface.

The exact spatial and temporal extent of migratory fish spawning and nursery designated use would vary annually due to regional climatic patterns if actual observed salinity and temperature were used to define year-by-year boundaries. Because use of year-by-year delineation of the exact boundaries of the migratory fish spawning and nursery designated adds complexity, a fixed set of boundaries was established. The migratory fish spawning and nursery designated use habitat shown in Figure IV-12 reflects both long-term, decadal average salinity conditions and decades’ worth of fisheries-independent beach seine and trawl monitoring data. States can adopt an approach (to be defined) for defining migratory spawning and nursery designated use boundaries on a year-to-year basis by directly factoring in the influence of interannual climatic patterns on the use boundaries.

Open-Water, Deep-Water and Deep-Channel Designated Use Boundaries

Background

The open-water, deep-water and deep-channel designated uses, the habitats they represent and the dissolved oxygen criteria for ensuring their protection are inextricably related to physical structure (water-column stratification, bottom bathymetry) and to physical, chemical, meteorological and fluvial forces and processes. Understanding these factors will enhance understanding of the designated use delineation process as well as the issues underlying application of the dissolved oxygen criteria. The following section provides background on these three principal factors: bathymetry, flow and circulation, and vertical density gradients and pycnoclines.

Bathymetry

Although the Chesapeake Bay is a relatively shallow estuary, bathymetric features play a large role both in defining the Bay's habitats as well as the eutrophication-related water quality problems observed throughout most of the tidal waters.

The most prominent bathymetric feature in the Bay is the deep trench that runs from the Chesapeake Bay Bridge between Annapolis and Kent Island, Maryland, to an area midway between the southern shore of the mouth of the Potomac River and the northern shore of the mouth of the Rappahannock River (figures IV-13 and IV-14). The trench ranges from 24 to 48 meters in depth and extends generally midchannel between the western and eastern shores of the mainstem Chesapeake Bay. It is thought to be a remnant of the ancient Susquehanna River. A shallower trench extends down along the Virginia Eastern Shore (Figure IV-15). Similar, smaller trenches and holes exist elsewhere in Bay tidal waters, generally in the larger tidal tributary rivers near their mouths. These are described later in the more detailed regional descriptions that follow.

These deep regions contrast with the Chesapeake Bay as a whole, which has an average depth of only 6 meters. They also figure prominently in the Chesapeake Bay's dissolved oxygen problems. When it is overlain by a stratified water column, the bottom water in the trenches and holes is isolated from the oxygenated surface water and can become oxygen-depleted. This situation generally occurs in the late spring and summer when oxygen-consuming activity is high and discontinuity in water density through the water column can act as a barrier, i.e., act as a 'lid,' capping off the exchange of oxygenated water with the oxygen-depleted waters in the trenches and holes. However, some of the deep areas of the Chesapeake Bay, although capped as described, do not suffer from chronically low dissolved oxygen. These areas generally have their downstream or seaward end open so that deep-water exchange with the oxygenated deep water from the ocean can occur.

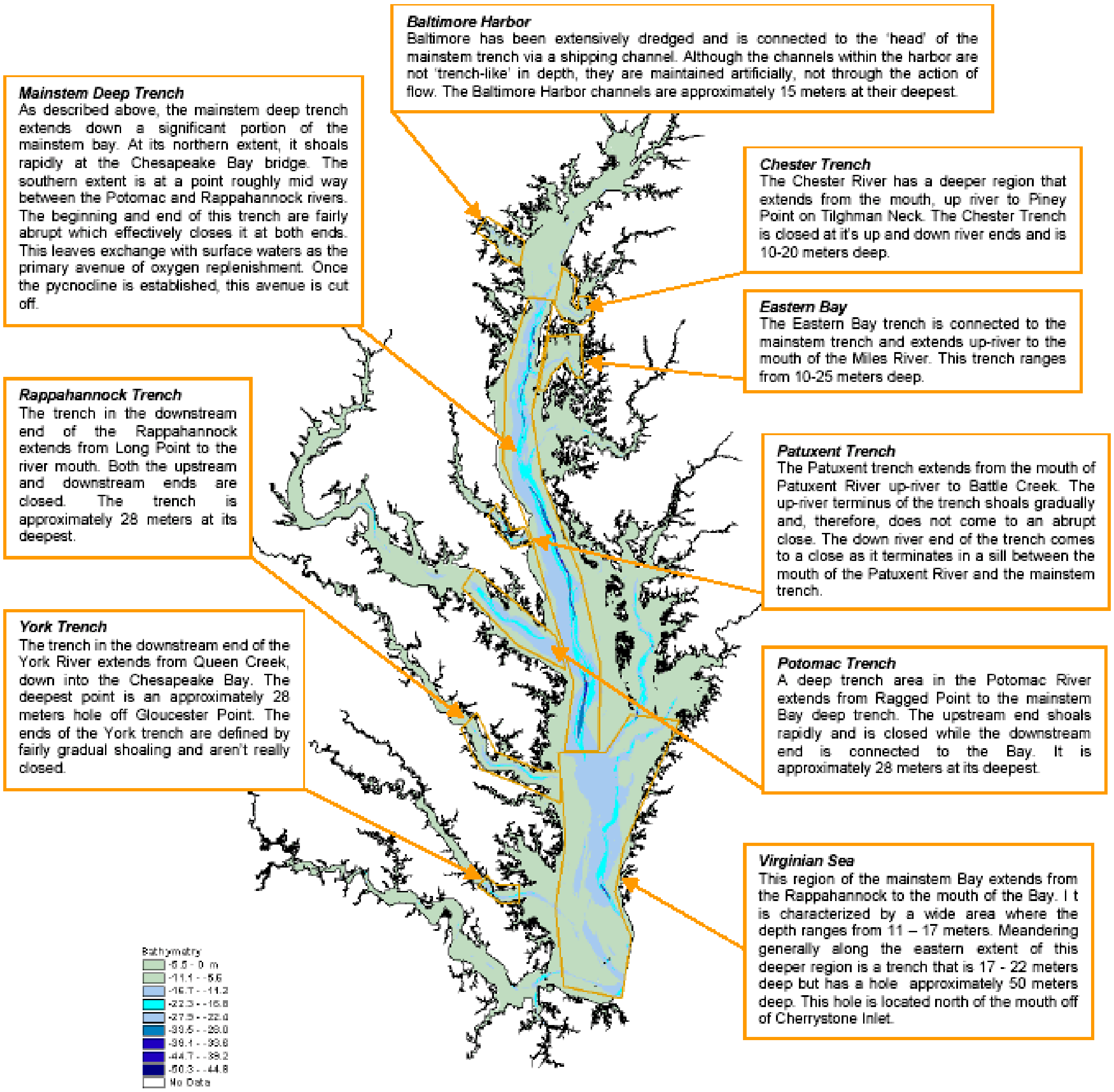

Figure IV-13. Major bathymetric trenches within the Chesapeake Bay and its tidal tributaries.

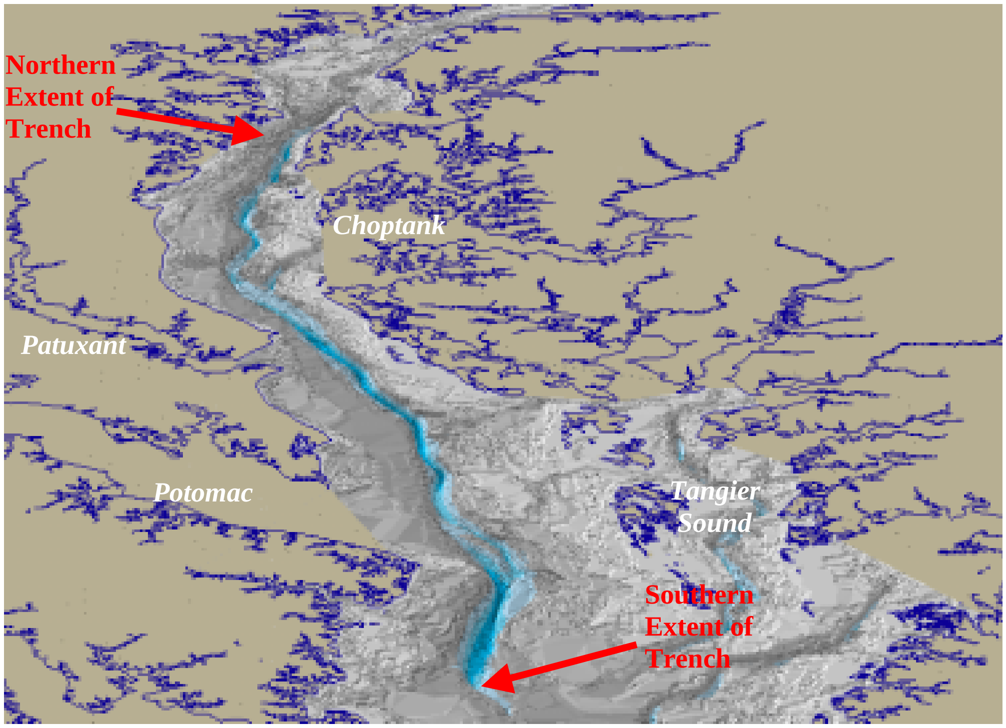

Figure IV-14. Three-dimensional view of the Chesapeake Bay mainstem trench as viewed from the south looking north. The depth versus width relationship has been enhanced to improve viewing.

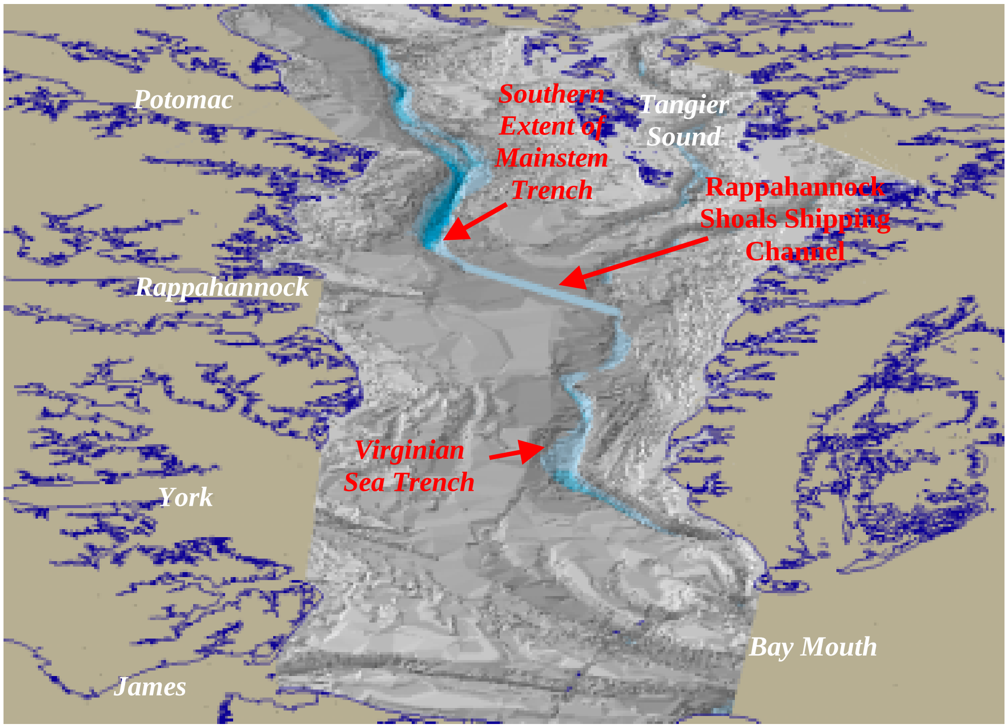

Figure IV-15. Three-dimensional view of the 'Virginian Sea' as viewed from the south looking north. The depth versus width relationship has been enhanced to improve viewing.

Flow and Circulation

Processes within the Chesapeake Bay and its tidal tributaries are strongly influenced by flow and circulation patterns. These factors affect the mixing of the Bay's waters and the distribution of salinity, dissolved compounds and planktonic organisms. Like most estuaries, the Chesapeake Bay has a two-layer flow pattern. Net flow in the upper layer moves down the Bay or downriver, while net flow in the bottom layer moves up the Bay or upriver.

This two-layer flow is caused primarily by the difference in density between the less dense, low-salinity water that flows off the land and the more dense, high-salinity water that flows in from the ocean. The less dense, more buoyant, low salinity water floats on the surface of higher salinity water. The tendency of ocean water in summer to be cooler than freshwater also contributes to its higher density. Interannual and seasonal differences in freshwater inflow to the rivers and the Chesapeake Bay, due largely to meteorological factors, affect the interaction of the two layers.

Tidal forces move water into and out of the Chesapeake Bay and its rivers. Tidal currents interact with the bathymetric surfaces of the bottom, with the seaward flow of freshwater and with the air-water interface affecting internal turbulence and mixing. Tied to lunar cycles, the daily, monthly and seasonal tidal rhythms are relatively predictable components of flow and circulation.

The Coriolis force is another important physical circulation process in the Chesapeake Bay. The Coriolis force is related to the earth's rotation and causes moving objects such as fluids to veer to the right (clockwise) in the Northern Hemisphere and to the left (counter-clockwise) in the Southern Hemisphere. This force increases with proximity to the poles. Currents in the Northern Hemisphere tend to move clockwise over their course unless they encounter a barrier such as a land mass. Thus ocean water flowing into the Chesapeake Bay at the mouth is deflected north due to the Coriolis force. The current continues around to the right until it encounters the Eastern Shore, which directs the flow up the Bay. Water flowing down and out of the Chesapeake Bay on the surface, flows primarily down the Western Shore as the Coriolis force tends to push it to the right. This same phenomenon of inflow on the bottom on the right and outflow on the surface on the left occurs in the Bay's tidal tributaries as well.

Vertical Density Gradients and Pycnoclines

In many parts of the Chesapeake Bay, the water column becomes stratified because of differences in water density. These differences are caused primarily by differences in salinity and, to lesser degree, in temperature. The water column becomes vertically stratified when, at some depth, a difference in water density from one depth to the next is large enough to inhibit or prevent exchange between water above and below it. Fisher et al. (2003) found the density gradient for defining inhibition or prevention of water exchange in the Chesapeake Bay to be 0.1 kg/m^4. The depth nearest the surface where this first occurs is referred to as the pycnocline. The discontinuity may be gradual, as shown in Figure IV-16a, exhibiting a generally uniform gradient of increasing density from one depth to the next through the water column. In such cases, one refers to the *region* of the pycnocline.

In areas where stratification is common, the pycnocline typically forms at about the same depth, but is subject to seasonal and annual variations in depth due to river flow, temperature and salinity patterns. The pycnocline is generally shallower at the mouths of tidal rivers and the Chesapeake Bay and deeper with distance upriver and up-Bay. In the central, deepest part of the mainstem Chesapeake Bay, the pycnocline tends to deepen and 'tilt' slightly on the east-west axis, depending on the strength and direction of prevailing winds as well as the relative balance of the several forces controlling Chesapeake Bay circulation. North of this area, where the Bay narrows and grows shallow, and north-moving bottom water shoals up from the deep trench, the pycnocline is generally found closer to the surface. In upriver areas of tidal tributaries, pycnoclines may occur occasionally depending on episodic intrusions of saline waters. In other areas, such as the mouth of Tangier Sound in the lower Chesapeake Bay, pycnoclines are occasional or intermittent because fresh and saline waters are typically well-mixed by tidal currents and bathymetric features.

In some areas, the many factors acting on circulation create a more complex stratification structure. Below the surface mixed layer, there is a layer where density continues to change with depth. Then a second, sharp density discontinuity is encountered, creating a discrete bottom mixed layer (Figure IV-16b). A density gradient of 0.2 kg/m^4 was found to inhibit upward vertical exchange and form a boundary for this lower mixed zone. (See Appendix D for a more thorough explanation of the methods for determining the pycnocline.)

For these reasons, the shape of a density profile can be highly variable within and between locations. The profile in Figure IV-16b is common in medium-to-deep areas of the mainstem Chesapeake Bay and lower tributaries during the summer months. There is an upper mixed layer several meters thick, followed by a distinct change in the density gradient. This change marks the upper depth of the pycnocline and the lower depth of the upper mixed layer. The thickness of the inter-pycnocline region in this example is 9 meters, about a third of the water column. The bottom mixed layer is fairly thick in this case, extending approximately 13 meters to the bottom. The figure illustrates the effect of the pycnocline and density gradient on oxygen concentration in this part of the Chesapeake Bay. Oxygen in the surface mixed layer is close to saturation. Below the upper pycnocline depth, oxygen levels fall with increasing distance from the oxygenated upper layer. The bottom mixed layer is consistent at about 1 mg/l through the entire thickness to the bottom.

Figure IV-17a shows a pycnocline type that is common to shallow to medium-depth areas of the mainstem Chesapeake Bay and mid-to-lower areas of the tidal tributaries. There is a well-defined surface mixed layer, marked by a sharp density discontinuity, but no lower mixed layer. The pycnocline extends through the water column to the bottom sediment-water interface, with dissolved oxygen concentrations decreasing with distance from the upper pycnocline boundary. Figure IV-17b shows a different density structure at the same location on a different date. There is no density discontinuity, the upper mixed layer extends through the entire water column and dissolved oxygen levels greater than 5 mg/l are sustained through to the bottom sediment-water interface. The vertical profiles in figures IV-17a and IV-17b are typical of tidal-fresh and shallow areas of the mainstem Chesapeake Bay and tidal tributaries and can frequently be observed in medium-depth regions of the mainstem Bay and mid- to lower sections of the tidal tributaries.

The relationship of dissolved oxygen to the presence or absence of a pycnocline and density gradient is different in the lower Chesapeake Bay mainstem (Figure IV-17c). A sharp pycnocline exists, but the gradient in dissolved oxygen concentrations is not as pronounced. Vertical mixing is still retarded by the pycnocline as in other areas of the Chesapeake Bay, but bottom waters are not as low in oxygen due to the replenishment of oxygenated waters from the ocean.

Figure IV-18 is a snapshot of water density and dissolved oxygen profiles at various sites in the Chesapeake Bay during the summer of 1997. The lines depicting water density demonstrate the layering and mingling of water masses of different sources and histories within the confines of the trenches and on the shoals. The plots also illustrate the difference small and large variations in density can have on dissolved oxygen concentrations as described above. For example, at monitoring station EE3.2 in Tangier Sound, the decrease in dissolved oxygen concentration (about 2 mg/l) at 14 meters has a density difference just large enough to be considered a pycnocline. Downstream, at station CB7.2, the change in density is much larger but induces about the same magnitude of decrease in the dissolved oxygen concentration gradient.

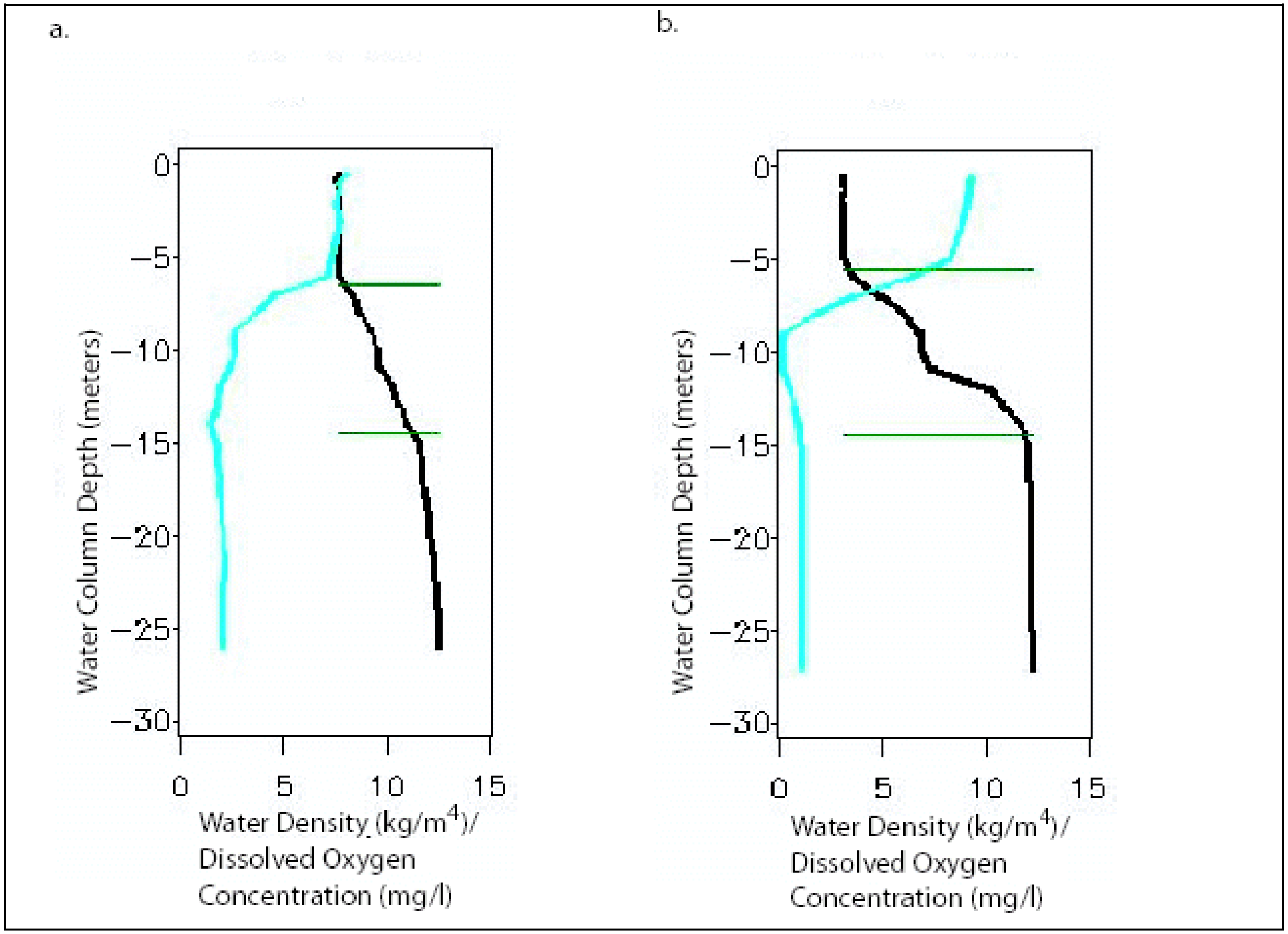

Figure IV-16. The figures illustrate a variety of water density and dissolved oxygen profiles found in the Chesapeake Bay and its tidal tributaries. The darker line represents water density (kg/m ^{4}), the lighter line represents dissolved oxygen concentration (mg/l). The vertical axis indicates depth (meters) below the surface. The horizontal line crossing the density line, when present, indicates upper and lower pycnocline depth using the Fisher et al. 2003 method. Figure ‘a’ is an example of a sharp, upper pycnocline with density gradually increasing with distance from the surface. Figure ‘b’ is an example of a more distinct three-layer structure.

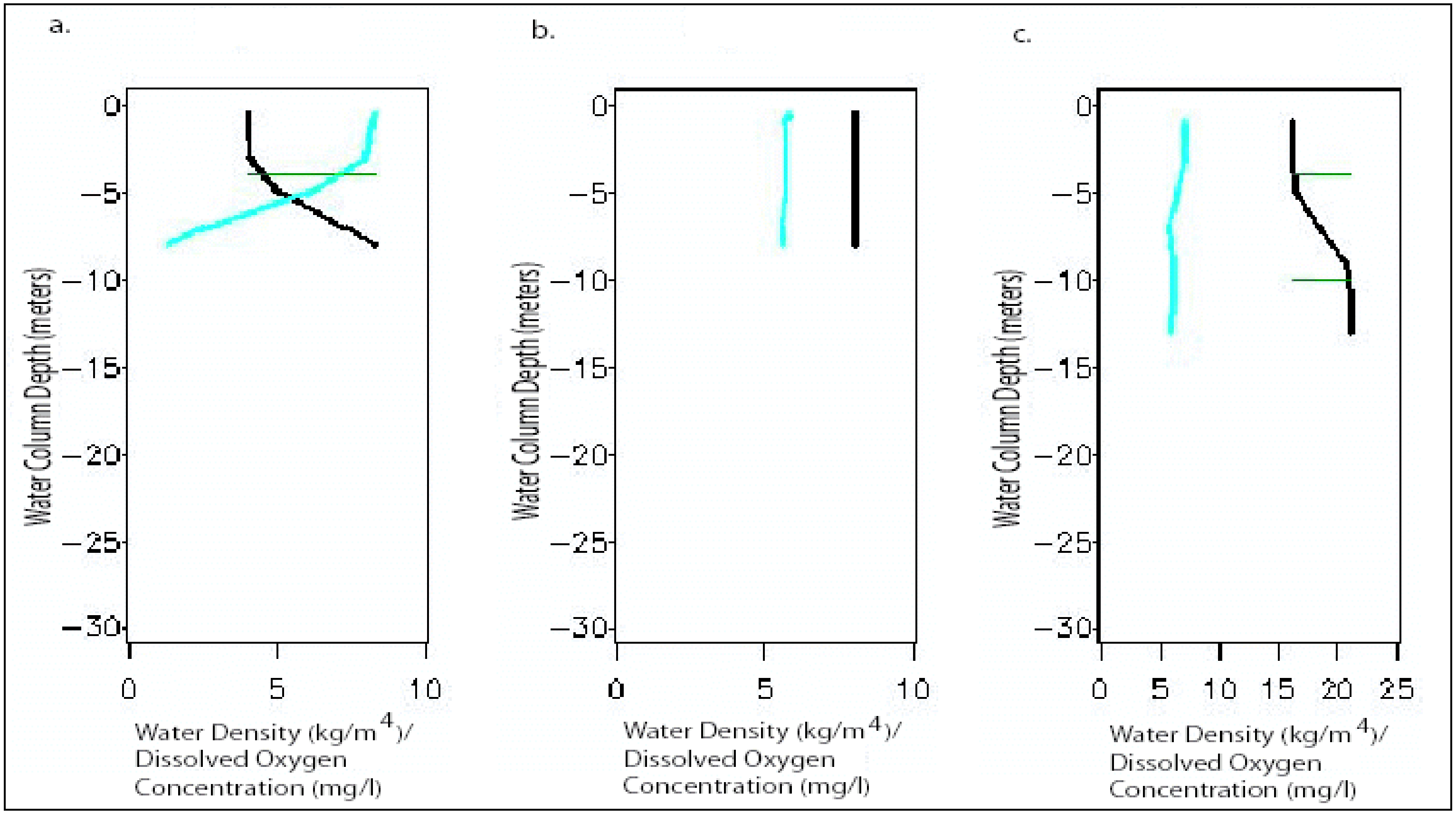

Figure IV-17. The figures illustrate a variety of water density and dissolved oxygen profiles found in the Chesapeake Bay and its tidal tributaries. The darker line represents water density (kg/m ^{4}), the lighter line represents dissolved oxygen concentration (mg/l). The vertical axis is depth (meters) below the surface. The horizontal line crossing the density line, when present, indicates upper and lower pycnocline depth using the Fisher et al. 2003 method. Figure ‘a’ represents vertical profiles of density and dissolved oxygen concentration at a relatively shallow site. A layer of homogenous, oxygenated low salinity water lies over water with a gradually increasing salinity/density gradient. Figure ‘b’ represents vertical profiles of density and dissolved oxygen at the same relatively shallow site when the water column is fully mixed. Figure ‘c’ represents vertical profiles of density and dissolved oxygen at a site in the lower mainstem Chesapeake Bay where dissolved oxygen levels are sustained throughout the water column in the presence of a density gradient and pycnocline.

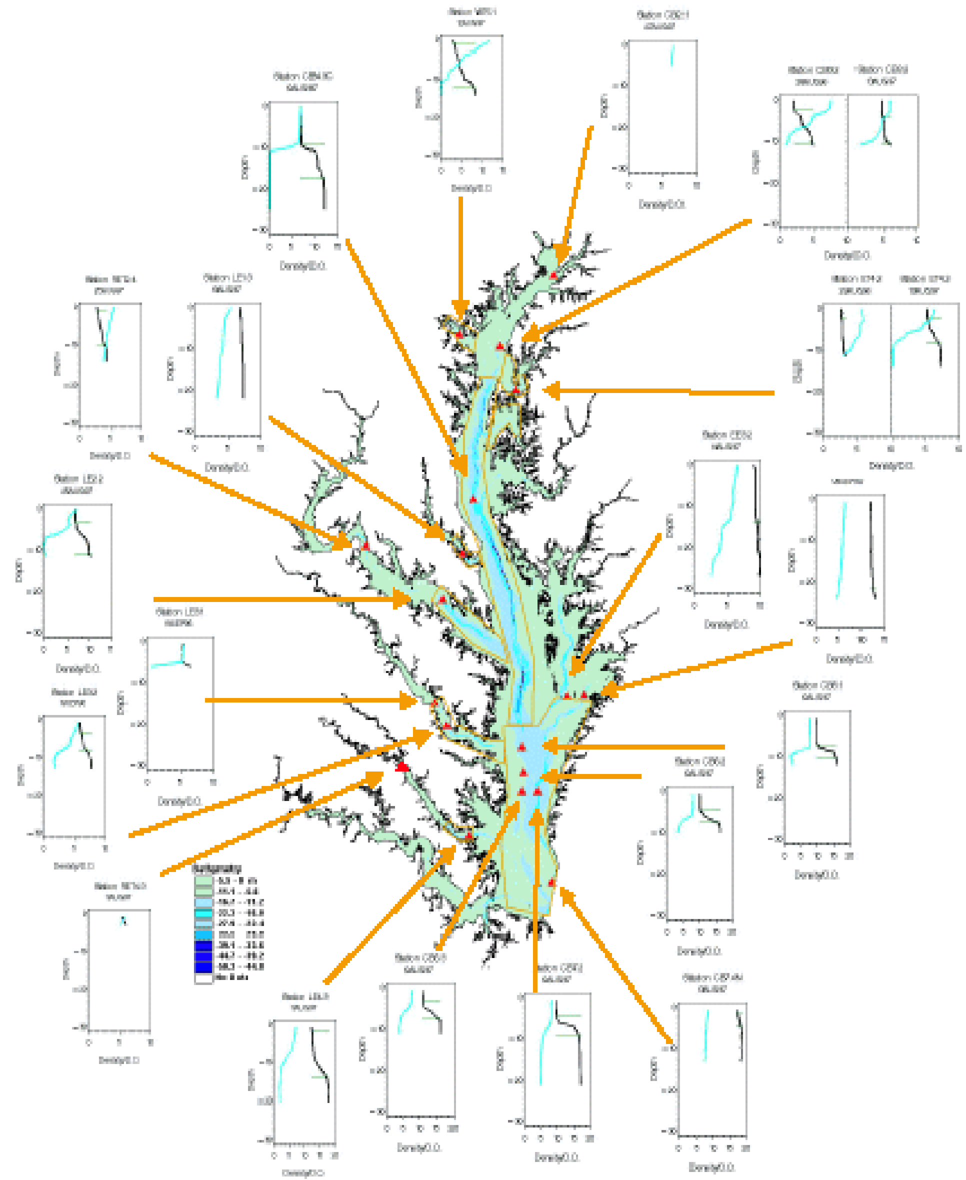

Figure IV-18. 'Snapshot' of water density and dissolved oxygen vertical depth profiles at various water quality monitoring program stations in the Chesapeake Bay and its tidal tributaries in the summer of 1997.

Delineating the Designated Use Boundaries

Vertical stratification has direct implications for delineating the designated use boundaries. Much of the water in the Chesapeake Bay and its tidal tributaries is shallow and well-mixed or easily aerated. These areas plus the surface mixed layers overlying stratified water in channels and holes constitute the open-water fish and shellfish designated use. The upper layer mixes on time scales of minutes to hours (Alldredge et al. 2002), which means that all of the water in this layer comes in close contact with the atmosphere and should be able to attain the most protective surface water dissolved oxygen criterion. The open-water designated use boundary is, therefore, defined as the upper mixed layer, extending from the water surface to the bottom water-sediment interface, where no stratification occurs or to the measured depth of the upper pycnocline where, in combination with bottom bathymetry and water-column circulation, it presents a barrier to oxygen replenishment of deeper waters. From June through September, the open-water designated use accounts for approximately 70 percent of the total volume of the Chesapeake Bay and its tidal tributaries, and many Chesapeake Bay Program segments have only this one designated use (Table IV-8).

Water in the bottom mixed layer is essentially trapped. The bottom mixed layer is separated from the upper mixed layer by the pycnocline and receives very limited oxygen from either mixing or diffusion. Biological respiration and decomposition processes deplete the ambient dissolved oxygen, and bottom sediments exert additional oxygen demand. The shape of the bottom mixed layer or deep-channel designated use is essentially a thin layer along the bottom in most areas, with thicker sections in some deeper areas of the Chesapeake Bay. Water within the pycnocline between the upper and lower mixed layers is defined as the deep-water designated use.

However, as noted and illustrated above, a pycnocline and density gradient do not affect dissolved oxygen concentration conditions to the same degree in all areas of the Chesapeake Bay and its tidal tributaries. There are regional peculiarities in bathymetry and flow that strongly influence the effect of a pycnocline on dissolved oxygen concentrations, and these must be taken into account.

Table IV-10. The tidal-water volume of the designated uses by Chesapeake Bay Program segment.

Chesapeake Bay Program Segment	Volume (cubic kilometers)			
	Migratory	Open-Water	Deep-Water	Deep Channel
CB1TF	.35/4%	.35/1%		
CB2OH	1.22/14%	1.23/2%		
CB3MH	2.27/27%	1.05/2%	.87/6%	.47/5%
CB4MH		4.26/9%	2.73/9%	2.25/26%
CB5MH		7.57/15%	3.17/15%	4.62/52%
CB6PH		5.03/10%	5.03/10%	
CB7PH		10.29/21%	10.29/21%	
CB8PH		3.16/6%		
PAXTF		.01/<1%		
PAXOH	.03/<1%	.03/<1%		
PAXMH	.39/5%	.38/1%	.38/1%	
POTTF	.48/6%	.48/1%		
POTOH	.84/10%	.84/2%		
POTMH	1.16/14%	3.17/6%	1.25/9%	1.20/14%
RPPTF	.10/1%	.10/<1%		
RPPOH	.05/<1%	.05/<1%		
RPPMH	.17/2%	1.00/2%	.33/2%	.13/1%
PIAMH		.20/<1%		
MPNTF	.01/<1%	.01/<1%		
MPNOH	.03/<1%	.04/<1%		
PMKTF	.02/<1%	.03/<1%		
PMKOH	.06/<1%	.06/<1%		
YRKMH	.08/1%	.28/1%		
YRKPH		.24/<1%	.15/<1%	
MOBPH		1.33/3%		
JMSTF	.26/3%	.27/<1%		
JMSOH	.42/5%	.43/1%		

Chesapeake Bay Program Segment	Volume (cubic kilometers)			
	Migratory	Open-Water	Deep-Water	Deep Channel
JMSMH	.36/4%	.97/2%		
JMSPH		.43/1%		
SBEMH				
ELIPH				
CHSMH				
EASMH	.05/<1%	.78/2%	.09/1%	.12/1%
CHOOH	.04/<1%	.04/<1%		
CHOMH1	.02/<1%	.95/2%		
CHOMH2	.12/1%	.26/1%		
POCMH		.35/1%		
TANMH		3.98/8%		
Total	8.54/100%	49.65/100%	13.41/100%	8.79/100%

The Boundary Delineation Process

The process of identifying and delineating the open-water, deep-water and deep-channel designated use boundaries employed observed and model-simulated characterizations of dissolved oxygen concentrations and the theoretical effects of the physical and chemical processes discussed above. The process first identified the deep-channel designated use habitats: the areas of the Chesapeake Bay and its tidal tributaries that suffer chronic low dissolved oxygen concentrations due to the natural interplay of water-column stratification, bottom bathymetry and water circulation patterns. These areas are so strongly isolated by these factors that they become immune from remediation. The next step was to identify the deep-water designated use habitats–areas with chronically low dissolved oxygen concentrations driven largely by water-column stratification, bottom bathymetry and water circulation patterns, but with hypoxic conditions (extent and severity) that are responsive to change, including changes in anthropogenic inputs. The rest of the tidal Bay habitats were identified as open-water designated use habitats.

First it was necessary to identify potential areas for delineation as deep-channel and deep-water designated use habitats by examining empirical dissolved oxygen concentration and distribution data under the ‘best’ observed conditions. The 17-year dissolved oxygen record from the Chesapeake Bay Program’s Water Quality Monitoring Program, 1984-2000, was reviewed to find the best summer dissolved oxygen conditions in this time period.[11] Using hypoxic volume-days as the metric, 1997 was chosen. The dissolved oxygen conditions of that year largely reflect the effect of low freshwater inflow and lower nutrient and sediment inputs from reduced rain and subsequent runoff.

Maps of bottom-water dissolved oxygen concentrations in the summer of 1997 revealed the areas with the most recalcitrant low dissolved oxygen concentrations. These maps also revealed areas with adequate dissolved oxygen concentrations, but with episodic low dissolved oxygen concentrations under other flow and runoff loading conditions. Maps of the spatial extent of waters with concentrations of 1 mg/l and 3 mg/l over the 17-year period helped identify areas where physical processes strongly influence dissolved oxygen concentrations and where low dissolved oxygen persists over a wide range of flows and associated nutrient loads. The regions identified as having chronic low dissolved oxygen concentrations attributable to the combined affects of pycnocline, bathymetry and flow were as follows:

- Upper, middle and lower central Chesapeake Bay segments (CB3MH, CB4MH and CB5MH);
- Northern reaches of the western and eastern lower Chesapeake Bay (CB6PH and CB7PH);
- Patapsco River (PATMH);
- Mesohaline segments of the Chester, Eastern Bay, Patuxent, Potomac and Rappahannock rivers (CHSMH, EASMH, PXTMH, POTMH and RPPMH); and
- Polyhaline segment of the York River (YRKPH) (Figure IV-19).

Dissolved Oxygen and Temperature

As the temperature of a liquid increases, the ability of gases to dissolve into it decreases. In other words, as water gets warmer, the concentration of gases, such as oxygen, within it decreases. This change has implications for the Chesapeake Bay in the summer time because, as the waters temperature increases, it can hold less and less oxygen. The inability to hold oxygen happens at a time when overall metabolism in the Bay is increasing with temperature. Higher metabolism is coupled with increased dissolved oxygen consumption.

How water-column stratification, bottom bathymetry and water circulation patterns affect dissolved oxygen conditions and, therefore, the designated use boundaries in each of these regions are discussed and illustrated below.

Upper Central Chesapeake Bay

The upper central Chesapeake Bay, or segment CB3MH, includes the 'head' of the mainstem Chesapeake Bay trench at its southern border near the Chesapeake Bay Bridge (Figure IV-19). In this segment the flow shifts from a single to a two-layer flow. The exact point where this occurs shifts south and north as the flow from the Susquehanna River increases and decreases with

[11] Historical dissolved oxygen data were available from as early as the 1950s; however, the temporal and spatial coverage was uneven and too coarse for this analysis.

seasonal and interannual variation. Its location in the center of this estuarine transition zone puts segment CB3MH at the extreme end of oxygen dynamics in the Chesapeake Bay. As ocean water moves up the Bay beneath the pycnocline, metabolic processes are consuming its reserve of dissolved oxygen. By the time this water reaches segment CB3MH, it has traveled approximately 220 kilometers and, depending on the time of year, it can be partly or completely deprived of dissolved oxygen. Because of this, the very southern portion of segment CB3MH is the first part of the Chesapeake Bay mainstem to show oxygen depletion in the spring and the last to become reoxygenated in the fall. As the northward-flowing bottom water encounters the head of the mainstem trench, it spills into the shallower waters of the middle portion of segment CB3MH before meeting and mixing with the south-flowing waters of the Susquehanna River (Figure IV-20). Therefore, even though this middle portion of segment CB3MH is not ‘trench-like’ in depth, this area has deep-channel and deep-water designated uses.

Middle Central Chesapeake Bay

The middle central Chesapeake Bay, or segment CB4MH, encompasses the entire northern half of the Chesapeake Bay mainstem trench with the exception of the head, which lies in segment CB3MH (Figure IV-19). The trench runs 20 to 35 meters deep along the eastern side of the segment. Once a pycnocline develops in this segment, it acts as a lid over the trench and effectively isolates below-pycnocline waters from the overlying waters. The source of the below-pycnocline water in segment CB4MH is the already depleted below-pycnocline water of segment CB5MH (Figure IV-21). Therefore, the only source of dissolved oxygen for below-pycnocline segment CB4MH water is the occasional storm-induced downwelling event. Given the size of this segment, these events are relatively localized and short-lived. Because the pycnocline so effectively isolates the deeper waters in this segment, along with bottom bathymetry and water circulation patterns, these within-pycnocline waters are designated as deep-water and the below-pycnocline waters are designated as deep-channel designated use habitats.

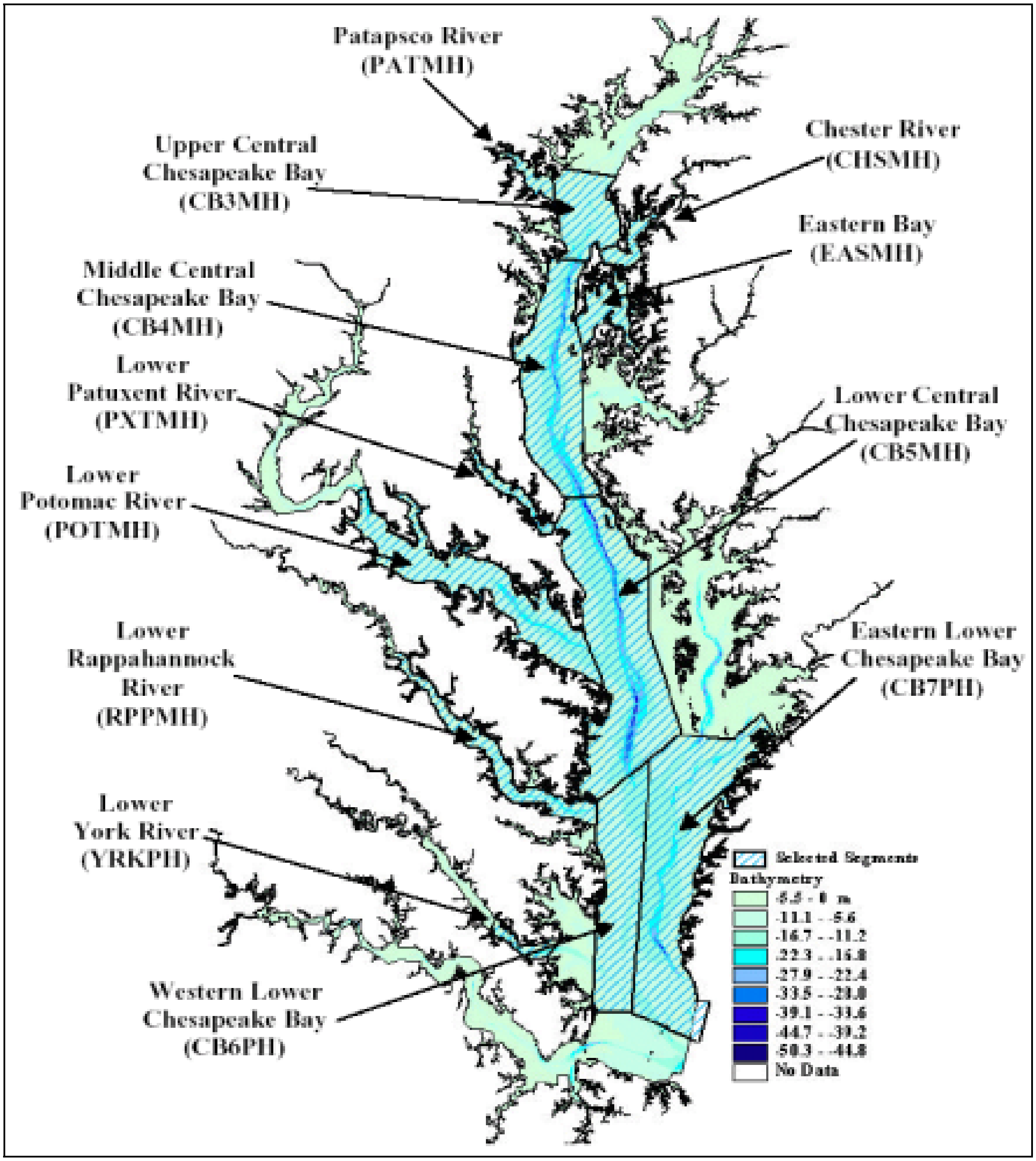

Figure IV-19. Chesapeake Bay Program segments identified as having chronic low dissolved oxygen attributable to the combined effects of pycnocline, bathymetry and flow.

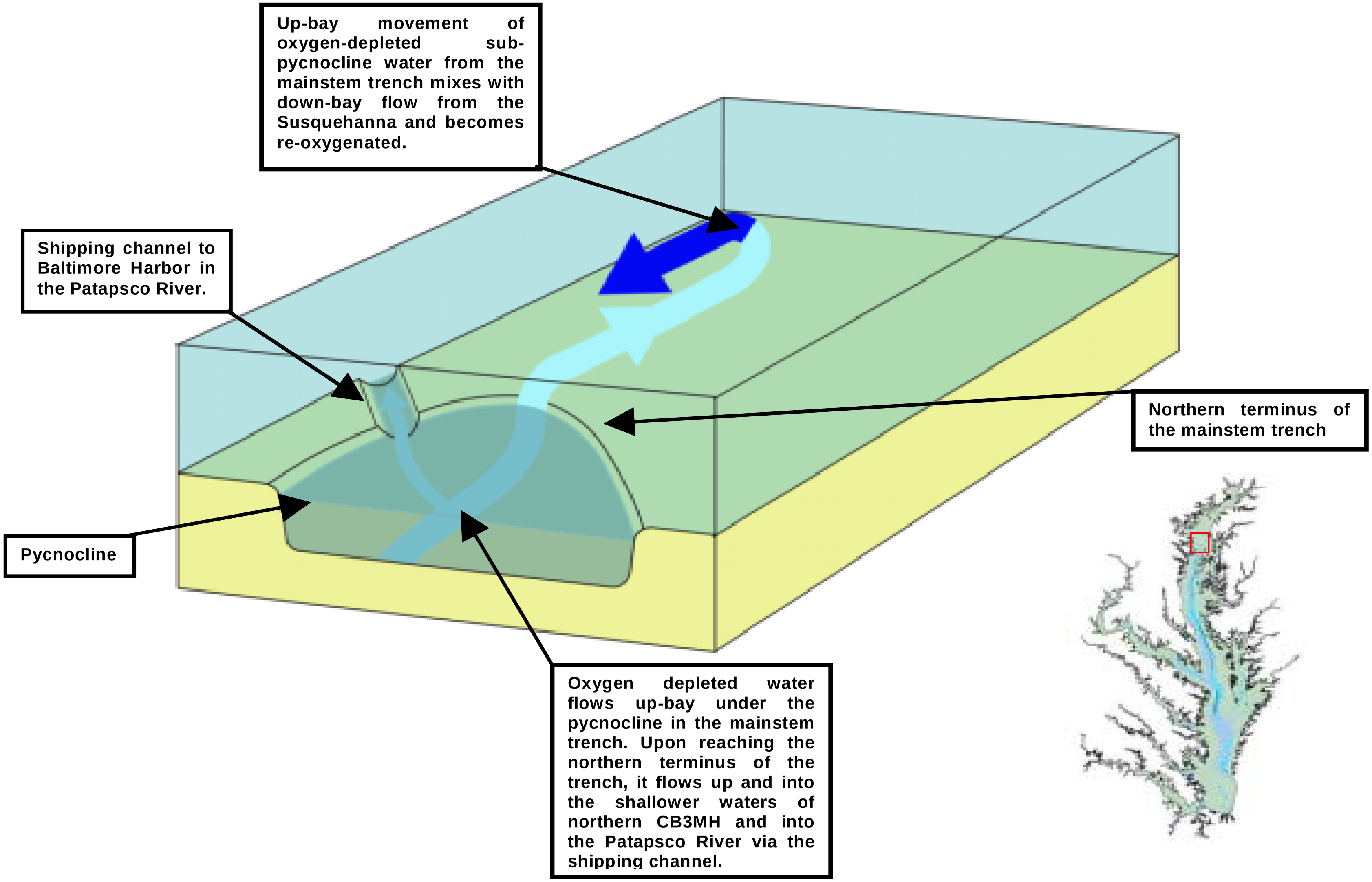

Figure IV-20. Three-dimensional schematic of the northern terminus of the mainstem Chesapeake Bay trench. Flow is depicted by thick arrows. Above- and below-pycnocline waters are shaded differently. Region depicted is boxed on inset map.

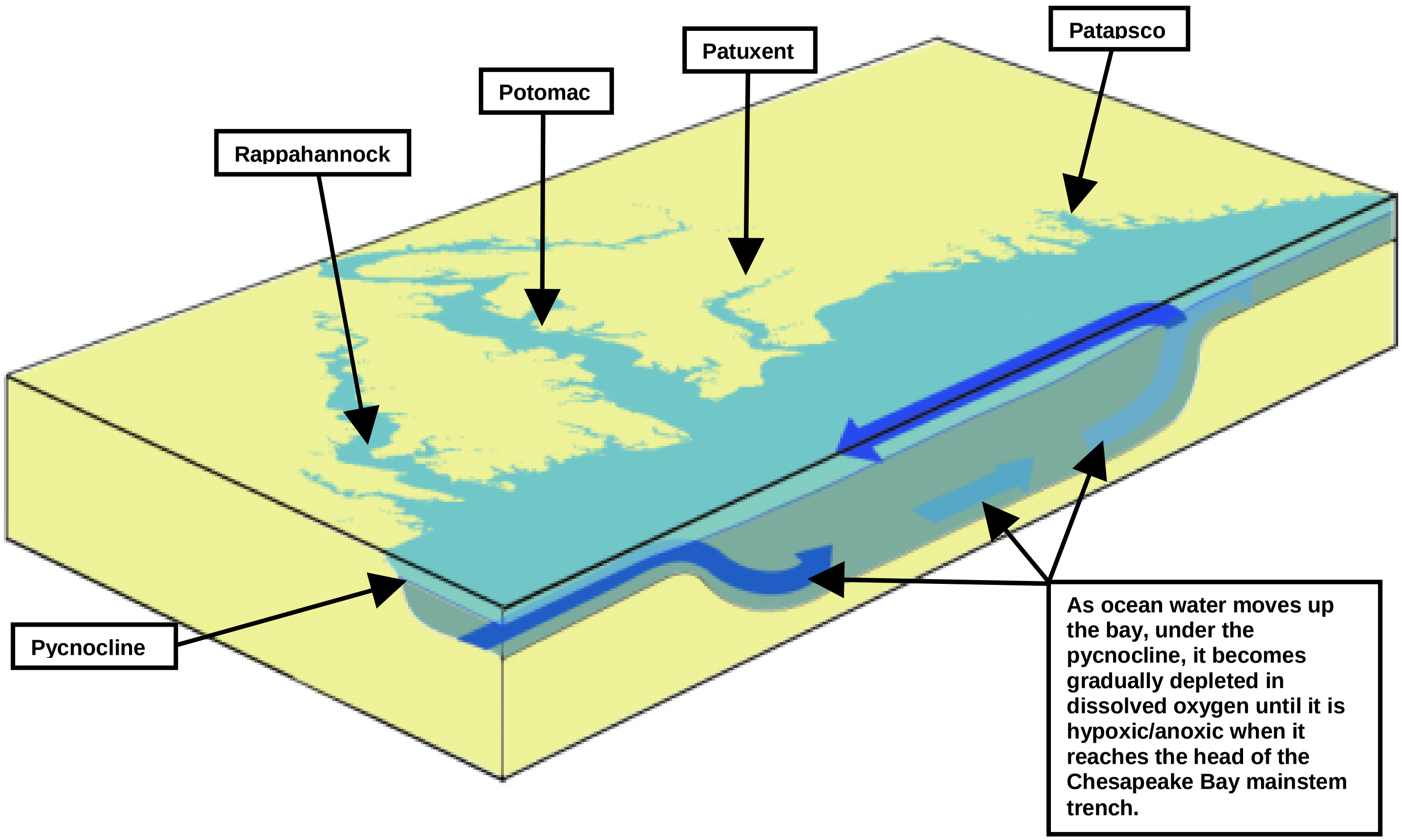

Figure IV-21. Three-dimensional schematic of the hydrodynamics of the Chesapeake Bay mainstem trench. View is from the southeast looking northwest.

The lower central Chesapeake Bay, or segment CB5MH, encompasses the entire southern half of the Bay's mainstem trench (see Figure IV-19). As in segment CB4MH, the pycnocline in this segment can 'cap' waters in the trench so that the only significant source of exchange is water flowing into the southern end of the trench, beneath the pycnocline. During most of the year, as this source water enters the trench, its dissolved oxygen concentration is still relatively undepleted, because it is not far from its ocean source. However, during July and August, temperatures in the southern mainstem Chesapeake Bay can be warm enough and benthic metabolism high enough for this source water to have depleted oxygen supplies (see "Dissolved Oxygen and Temperature" sidebar, above). As this water moves up the trench during the late spring and summer months, metabolic processes under the pycnocline gradually consume the available dissolved oxygen until it is severely depleted by the time it reaches the northern part of segment CB5MH (Figure IV-21). The southern half of segment CB5MH is generally the last part of the Chesapeake Bay mainstem to become oxygen-depleted and the first to become replenished. Because the pycnocline so effectively isolates the bottom waters in this segment, along with bottom bathymetry and water circulation patterns, the within-pycnocline waters are designated as deep-water designated use habitat and the below-pycnocline waters are designated as deep-channel designated use habitat.

Western and Eastern Lower Chesapeake Bay

The western and eastern lower Chesapeake Bay, segments CB6PH and CB7PH, respectively, together make up the broadest region of the Chesapeake Bay mainstem. The entire region is heavily influenced by the ocean. A 17- to 22-meter trench runs along the axis of segment CB7PH, extending from the northern end of the segment almost to its southern boundary (see Figure IV-19). The trench is approximately 2.5 kilometers wide and deepens to an approximately 50-meter hole near its southern terminus. Although the trench becomes capped by a pycnocline, below-pycnocline dissolved oxygen concentrations within the trench are usually not affected. As ocean water flows into the Chesapeake Bay mouth along the bottom, the Coriolis force swings this flow northward along the lower eastern shore of the Chesapeake Bay. This waterflow pattern carries ocean water directly into the trench in segment CB7PH and provides a steady supply of oxygenated water to the below-pycnocline habitats. Ocean water similarly replenishes the below-pycnocline waters of segment CB6PH.

Only the very northern portions of segments CB6PH and CB7PH appear to have a chronic dissolved oxygen depletion problem related to the pycnocline and local bottom bathymetry. The northern boundary of these two segments forms a line, inclining northeastward from the mouth of the Rappahannock River to a point at the southern tip of the islands forming Tangier Sound (see Figure IV-19). The line approximates the location of a broad shoal or sill on the Chesapeake Bay bottom. The sill defines the southern terminus of the mainstem Chesapeake Bay deep trench and functions as a 'hydrologic control point' for waters passing over it.

A shipping channel cuts through the sill, connecting the trench in segment CB7PH to the trench in the middle Chesapeake Bay (see Figure IV-22). The channel enables an exchange of oxygen-depleted bottom waters from the mainstem trench with water in the northern portions of segments CB6PH and CB7PH.

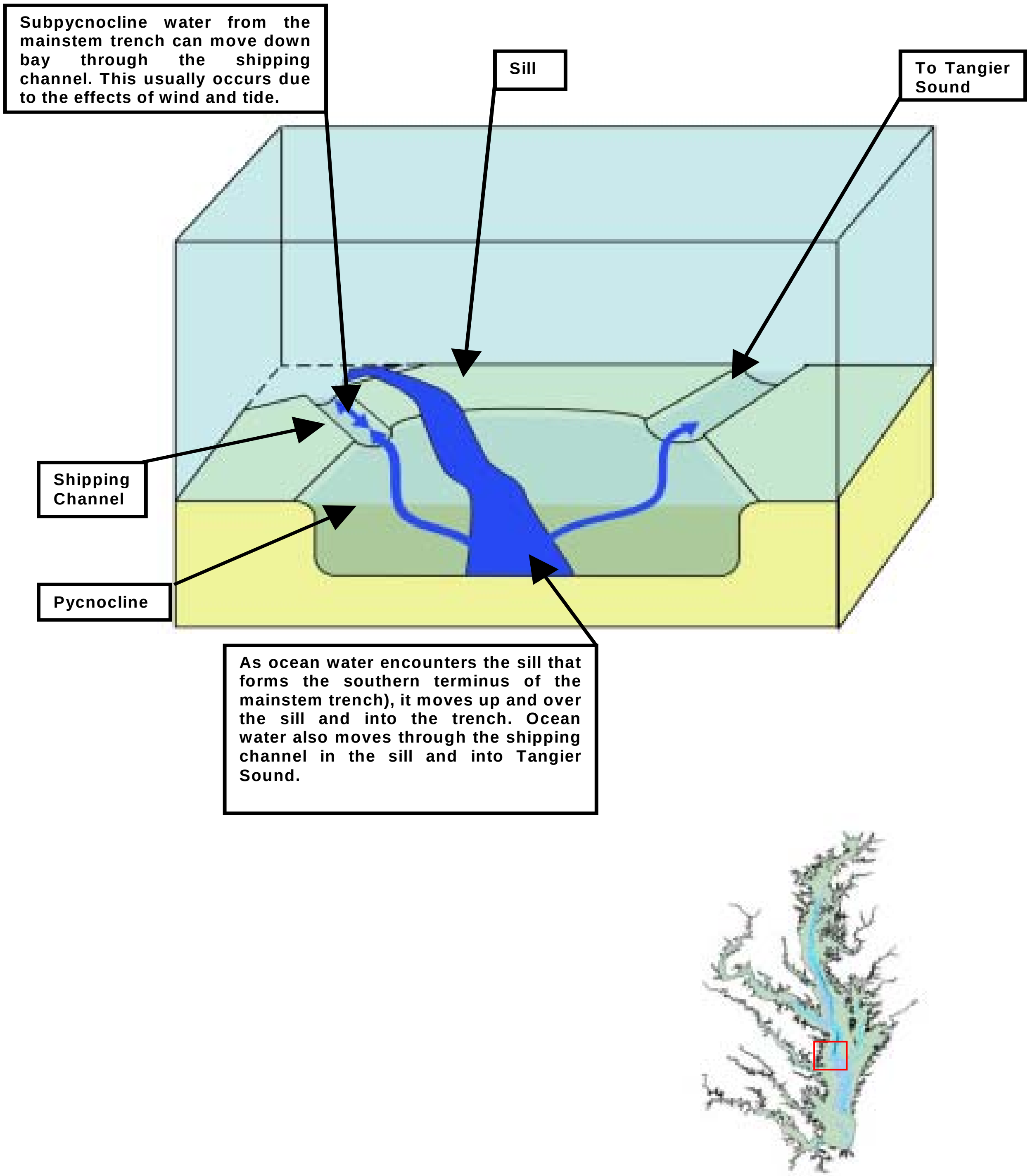

Figure IV-22. Three-dimensional schematic of the hydrodynamics of the northern portion of segments CB6PH and CB7PH. View is from the south. Area portrayed is boxed on the inset map.

Although the overall direction of flow in the bottom layer is northward in this region, the smaller-scale actions of the outgoing tide can pulse bottom waters down-estuary (Figure IV-22). Oxygen-deficient water intrudes on the bottom and as lenses into mid-water depths. This effect can be intensified during a strong north-westerly wind event (see sidebar, “Tides Affected by Moon and Sun”).

The deep-water designated use, therefore, extends below the sill in these two segments. Its lower boundary runs along a line more or less parallel to, but south of, the northern segment line (Figure IV-23). The delineation of the boundary was determined by examining maps of contemporary dissolved oxygen concentration distributions and the anecdotal historical dissolved oxygen concentration data record.

Patapsco River

The Patapsco River, segment PATOH, is a highly urbanized tidal waterway, home to a large industrial center and one of the largest shipping ports on the eastern seaboard. It is heavily and routinely dredged, and a significant portion of its shoreline has been hardened. Its shipping channel is directly connected to the Chesapeake Bay mainstem trench, allowing for the advection of oxygen-depleted water to its below-pycnocline layer (figures IV-20 and IV-24). The river has a complex three-layer flow structure. The middle, pycnocline waters of the Patapsco River are designated as a deep-water use, and the below-pycnocline waters are designated as a deep-channel use.

Chester River

The downriver, mesohaline portion of the Chester River, segment CHSMH, contains a trench that ranges in depth from 20 to 25 meters (see Figure IV-19). The trench is separated from the mainstem Chesapeake Bay by a sill. This sill can potentially affect dissolved oxygen levels in the deep waters of the trench that are chronically low in the summer months. The pycnocline can form a ‘lid’ over the trench, cutting off the exchange with surface waters. Because of the sill at the mouth of the river, tidal flushing by bottom waters can be restricted, reducing the replenishment of the bottom waters of the trench as well as the potential mixing force that the inflow might have. It may also be the case that during extreme (spring) tidal events (see sidebar, “Tides Affected by Moon and Sun,” above) low dissolved oxygen bottom

Tides Affected By Moon and Sun

Tides are controlled by the gravitational pull of the sun as well as the moon. When the moon and the sun are aligned, such as during a full moon or a new moon, tides achieve their highest highs and lowest lows. This phenomenon is called a ‘spring’ tide. When the pull of the sun and moon are at right angles, they act to cancel each other out, and tidal amplitude is at its lowest. This is called a ‘neap’ tide.

The higher amplitude tide that occurs during ‘spring’ tide results in increased tidal flow. This can be beneficial as when this increased flow advects oxygen rich water into and estuary. Conversely, it can be detrimental if the advected water is coming from deeper waters with low dissolved oxygen.

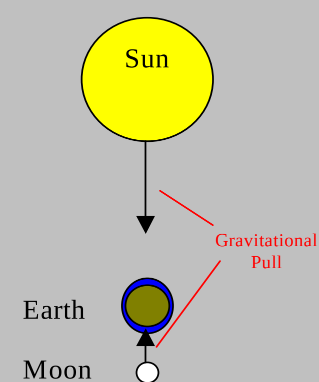

Diagram depicts ‘spring’ tide alignment of Sun and Moon.

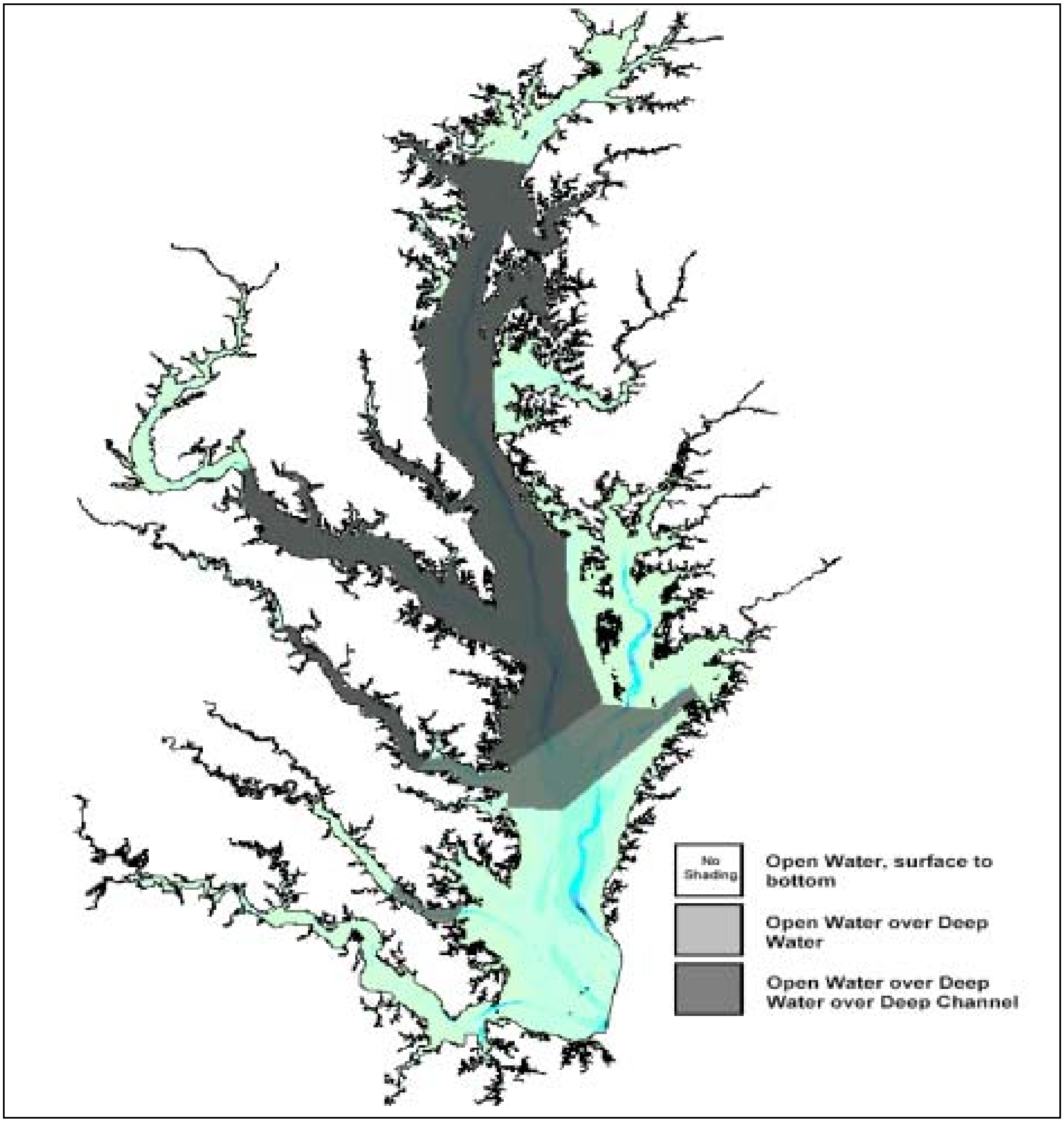

Figure IV-23. Map showing the dissolved oxygen designated uses of the Chesapeake Bay and its tidal tributaries.

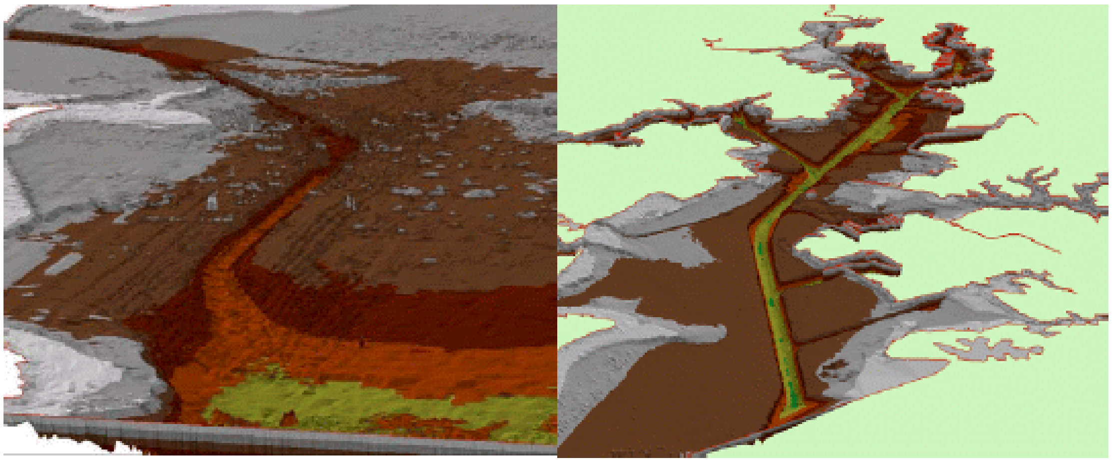

Figure IV-24. The image on the left shows the bathymetry of the shipping channel approach to Baltimore Harbor and how it is connected to the 'head' of the Chesapeake Bay mainstem trench at the bottom of the picture (middle to right side). The image on the right is of the bathymetry of Baltimore Harbor. To improve visualization, the depth versus width relationship has been enhanced.

water from the mainstem trench is advected into the Chester River trench, where it is sequestered under the pycnocline (Figure IV-25).

When a measurable pycnocline is observed (often due to these 'spill over events'), the within-pycnocline waters of the lower Chester River (river mouth up to the sill at Ringgold Point on Eastern Neck) have a deep-water designated use, and the below-pycnocline waters have a deep-channel designated use. In the absence of water-column stratification, the open-water designated use will apply throughout the water column to the bottom sediment-water interface in the lower Chester River.

Eastern Bay

In the Eastern Bay, segment EASMH, a trench extends from the river mouth, where it connects with the mainstem trench to a point halfway up the Bay (see Figure IV-19). This connection with the mainstem Chesapeake Bay trench has implications for dissolved oxygen in the bottom waters of lower Eastern Bay, since the below-pycnocline waters of this portion of Eastern Bay and the mainstem Chesapeake Bay trench exchange freely. This region of the mainstem trench has some of the worst dissolved oxygen conditions in the entire Chesapeake Bay. Because of this, below-pycnocline waters in lower Eastern Bay are chronically low in dissolved oxygen in summer. When a measurable pycnocline is observed, the within-pycnocline waters of Eastern Bay have a deep-water designated use and the below-pycnocline waters have a deep-channel designated use (see Figure IV-23). In the absence of water-column stratification, the open-water designated use will apply throughout the water column to the bottom sediment-water interface in Eastern Bay.

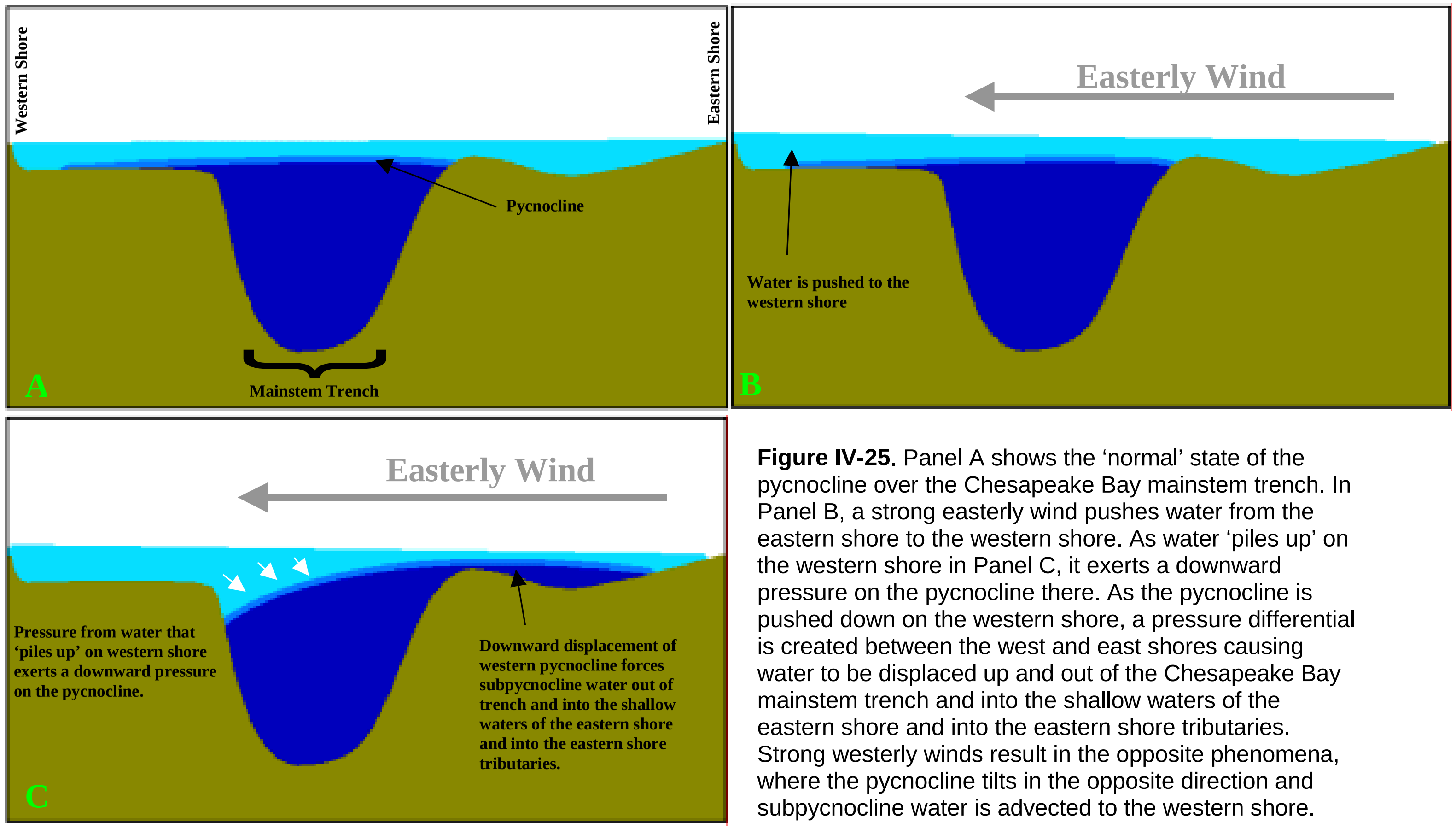

Figure IV-25. Panel A shows the 'normal' state of the pycnocline over the Chesapeake Bay mainstem trench. In Panel B, a strong easterly wind pushes water from the eastern shore to the western shore. As water 'piles up' on the western shore in Panel C, it exerts a downward pressure on the pycnocline there. As the pycnocline is pushed down on the western shore, a pressure differential is created between the west and east shores causing water to be displaced up and out of the Chesapeake Bay mainstem trench and into the shallow waters of the eastern shore and into the eastern shore tributaries. Strong westerly winds result in the opposite phenomena, where the pycnocline tilts in the opposite direction and subpycnocline water is advected to the western shore.

Patuxent River

The trench in the lower Patuxent River, segment PXTMH, contains one of the deepest points in the Chesapeake Bay just off of Point Patience. The Patuxent River trench terminates at a sill at the mouth of the river (Figure IV-26). Dissolved oxygen concentrations become depressed beneath the pycnocline in the summer, but not to the degree they do in the mainstem Chesapeake Bay trench. These depressed dissolved oxygen concentrations may be due to pycnocline-disrupting turbulence as the river flows through the constriction at Point Patience. Below-pycnocline dissolved oxygen does not become completely replenished, but these waters do naturally reoxygenate enough to maintain levels high enough for a deep-water designated use (see Figure IV-23). Given the depth of this trench, it is likely that hypoxia is a natural condition below the pycnocline in the summer.

Potomac River

The lower Potomac River trench, located in segment POTMH, extends from the mouth of the river up to Ragged Point and averages 15 to 25 meters deep (see Figure IV-19). A 10- to 15-meter shelf extends from the sides of the trench and connects with a similar region in the mainstem Chesapeake Bay (Figure IV-27). Although the Potomac trench is not connected to the mainstem Bay trench there is not a sill across the mouth of the Potomac. The pycnocline effectively isolates the water volume in the trench from the surface waters. In addition, given the size of the Potomac River watershed, a relatively large amount of organic matter could be delivered to the below-pycnocline waters of the Potomac trench. It is very likely that, due to the size and depth of this deep-water area coupled with strong water-column stratification, low dissolved oxygen conditions are a natural feature of the Potomac trench. The pycnocline waters of the lower Potomac River (POTMH) have a deep-water designated use and the below-pycnocline waters have a deep-channel designated use (see Figure IV-23).

Rappahannock River

The Rappahannock trench, located in segment RPPMH, extends from the mouth of the Rappahannock River to Belle Isle (see Figure IV-19). The downriver end of the trench terminates in a sill that extends across the mouth of the river. Dissolved oxygen concentrations in the bottom waters of the trench are affected by the formation of the pycnocline. However, bottom water in the upriver half of the trench is more affected than the downriver half. This phenomenon may be related to strong currents flowing in the Rappahannock River along the bottom and over the sill. Chao and Paluskiewicz (1991) found that lower-layer density currents flowing over a sill cause downward mixing upriver of the sill (Figure IV-28). If this downward mixing is occurring in the downriver half of the Rappahannock trench, it would explain why bottom water dissolved oxygen is less affected by the pycnocline in this region. In the Virginia rivers, bottom layer, upriver flow in the Rappahannock River is second only to that of the James River and is greater, on average, than in the Potomac River (Wang 2003, personal communication). Given this rapid upriver flow beneath the pycnocline, the below-pycnocline waters of the Rappahannock trench are not depleted of dissolved oxygen until they reach the head of the trench. Based on a decadal-scale analysis of dissolved oxygen within the trench, it appears that low dissolved oxygen in the upriver portion is a chronic condition.

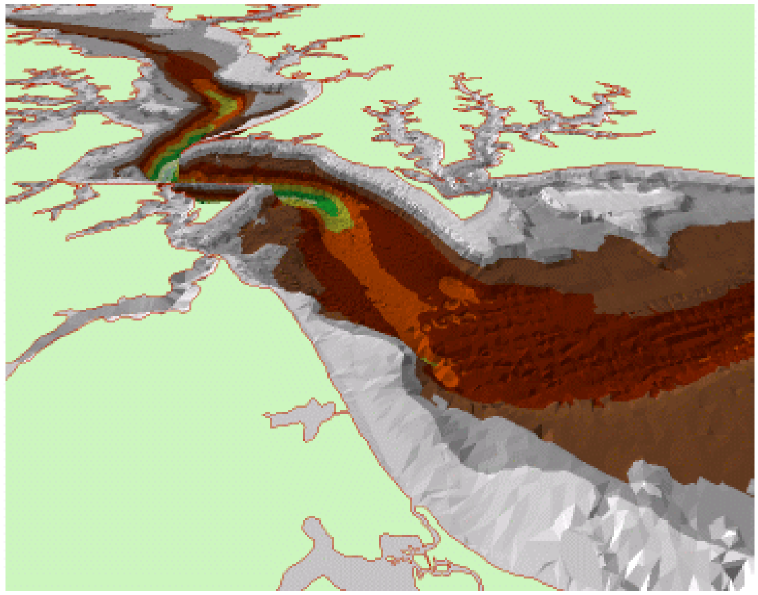

Figure IV-26. Bathymetry at the mouth of the Patuxent River. To improve visualization, the depth relative to the width has been enhanced.

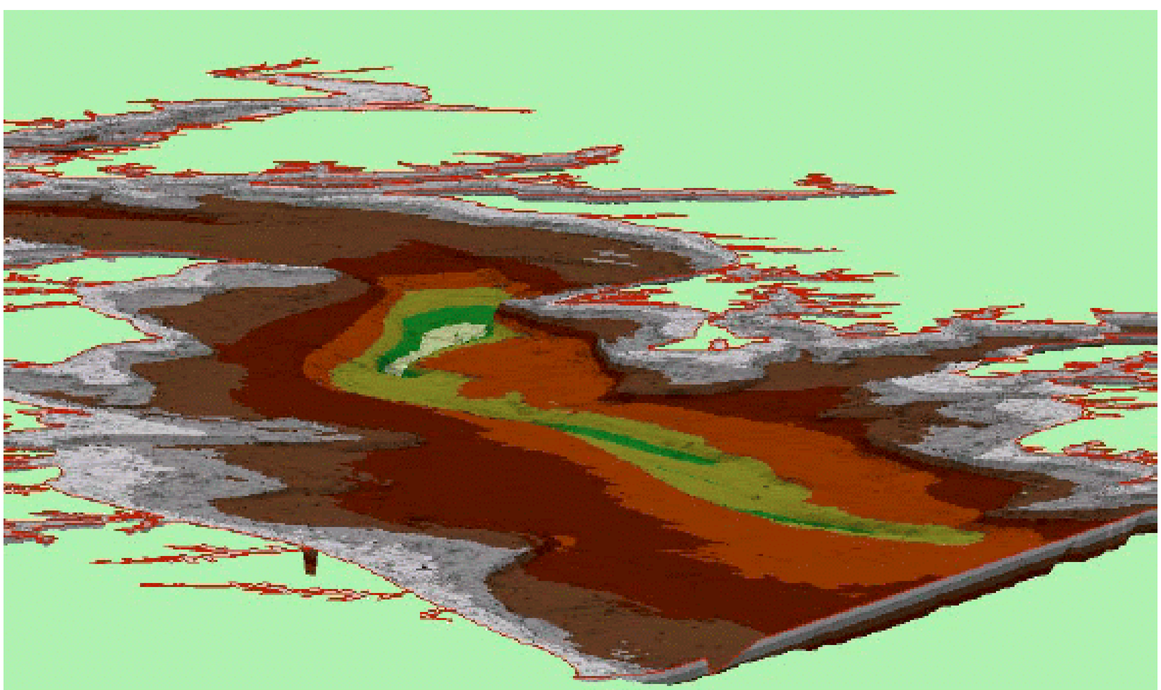

Figure IV-27. Bathymetry at the mouth of the Potomac River. To improve visualization, the depth relative to the width has been enhanced.

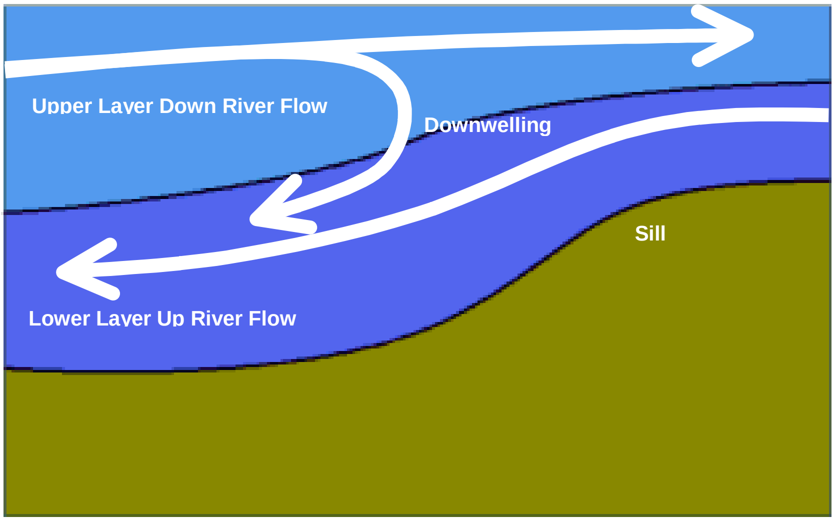

Figure IV-28. Diagram of the hydrodynamics of flow over a sill. As lower layer waters flow over the sill, downwelling surface waters occur.

Source: Chao and Paluszkiewicz 1991.

Because of the unique hydrodynamics of the lower Rappahannock River, the deep-water and deep-channel designated uses are not uniform across this segment. From the upriver shore of the Corrotoman River to the mouth of the Rappahannock River, the deep-water designated use extends from the upper pycnocline to the bottom sediment-water interface. Upriver of this section to Belle Isle, the pycnocline volume has a deep-water designated use and the below-pycnocline volume a deep-channel designated use (see Figure IV-23).

York River

The York trench, located principally in segment YRKMH, extends from where the York River empties into Mobjack Bay up-river to Kings Creek. A 10-15 meter channel runs from the down-river terminus of the trench, through Mobjack Bay to a point in the mainstem Bay adjacent to the Chesapeake Bay mouth (see Figure IV-19). This channel effectively connects the lower York River to ocean water flowing into the Chesapeake Bay. This connection apparently is a benefit to bottom water dissolved oxygen as concentrations below the pycnocline in this region do not get as low as they do in other below-pycnocline trench areas of the Bay. For this reason, the waters below the upper pycnocline down to the bottom sediment-water interface from the York River mouth to Timberneck Creek have a deep-water designated use (see Figure IV-23).

Shallow-Water Bay Grass Designated Use Boundaries

Restoration of underwater bay grasses to acreages supporting "the propagation and growth of balanced, indigenous populations of ecologically, recreationally and commercially important fish and shellfish inhabiting vegetated shallow-water habitats" is ultimately the best measure of attainment of the shallow-water bay grass designated use. Therefore, delineation of the shallow-water designated use boundaries must reflect the desired acreage of underwater bay grass restoration. In shallow-water habitats out to the 2-meter depth contour, the exact shallow-water designated use boundaries can:

- Follow a Chesapeake Bay Program segment-specific depth contour;

- Reflect an established segment-specific acreage of underwater bay grasses to be restored; or

- Match an established segment-specific acreage of shallow-water habitat required to meet the water clarity criteria.

The Chesapeake Bay Program segment-specific maximum depth of persistent, abundant underwater bay grasses growth sets the initial boundary for the habitat necessary for supporting the shallow-water designated use. That same segment-specific maximum depth was used in combination with the single best year of underwater bay grass distribution mapped across the available 1930-2000 data record to set the new restoration goals on a segment-by-segment basis. Finally, the ratio of the above shallow-water habitat out to the maximum depth of persistent, abundant plant growth and the corresponding segment-specific underwater bay grasses restoration acreage are used to calculate an acreage of shallow-water habitat meeting the water clarity criteria necessary to support achievement of the restoration goal acreage.

The following sections describe and quantify these three approaches to setting the shallow-water designated use boundaries, which are consistent with options the EPA put forth for measuring attainment of the Chesapeake Bay shallow-water underwater bay grass designated use (U.S. EPA 2003). EPA recommends the states adopt one (or more) of the three approaches to defining the shallow-water designated use boundaries in addition to adoption of numerical water clarity criteria into their water quality standards. States can adopt shallow-water designated use boundaries covering higher acreages or greater depths than those provided here during their upcoming water quality standards adoption processes once the expanded river-specific information has become available to be incorporated. During future state triennial reviews of their water quality standards, states also may expand their shallow-water designated use boundaries to reflect resulting levels of restoration of underwater bay grasses in prior years.

Maximum Depth of Persistent or Abundant Plant Growth-Based Boundaries

The 2-meter depth contour was selected as the maximum depth for the lower vertical boundary of the shallow-water designated use. This is the maximum depth to which underwater bay grasses could be restored in many of the tidal tributaries and mainstem Chesapeake Bay shallow-water habitats. Although historical underwater bay grass beds in the Chesapeake Bay probably grew to 3 meters or more, the 2-meter depth was chosen following an extensive evaluation of grass bed distribution over the past 70 years (1930s-2000) and of light levels anticipated to be required to restore viable shallow-water habitats out to the 2-meter depth (Batiuk et al. 1992; Dennison et al. 1993; Moore et al. 1999; Batiuk et al. 2000; Moore et al. 2001; Naylor 2002).

The intertidal zone was selected as the inner boundary for the shallow-water bay grass designated use because some species can grow in the upper end of the intertidal zone (Batiuk et al. 2000; Koch 2001). Numerous field studies of underwater bay grass distributions in the Chesapeake Bay and its tidal tributaries have indicated that what is controlling the minimum depth of their distribution is not wave action or other factors, but length of exposure to air at low tide (Moore, unpublished data; Naylor, unpublished data).

Shallow-water habitats also may be offshore flats such as those observed in Tangier Sound and Poquoson Flats in the lower mainstem Chesapeake Bay. These areas may have an inner boundary not in the intertidal zone but rather a relatively deep and wide channel between them and the shore. These areas are included in the delineation of shallow-water bay grass designated use habitats if they have or have had underwater bay grasses and met the decision rules described below.

Benefits of Deeper Underwater Bay Grass Distribution

There are obvious benefits to restoring underwater bay grasses to greater depths than where they currently exist in the Chesapeake Bay and its tidal tributaries (Table IV-10). Increasing the depth and, therefore, the areal distribution of the grasses can greatly increase the habitat and food available to the Chesapeake Bay's fish, crabs and waterfowl.

Table IV-10. Ecological benefits of restoring underwater bay grass beds to greater depths.

- Ensures growth of underwater bay grasses where previously there may have been none because wave energy at shallower depths prevented plants from rooting in the bottom sediments (e.g., the beds that formerly grew on the western side of Kent Island, Maryland, at depths greater than where the critical wave energy threshold exists);
- Adds habitat below the grazing depth of non-native mute swans and non-migratory Canada geese (approximately 1 and 0.5 meters, respectively) to increase food availability for native waterfowl;
- Reduces the likelihood of ice damage to the beds;
- Reduces the negative effects of unusually low tides;
- Minimizes thermal stress (as deeper beds are inherently cooler);
- Stabilizes sediments at greater depths (through the reduction of water velocity within the underwater bay grass beds);
- Increases overall nutrient uptake and supports increased denitrification;
- Increases summertime oxygen production (which is particularly important in the headwaters of tidal creeks); and
- Increases habitat for fish, crabs and macroinvertebrates.

It is important to note that underwater bay grass distribution is directly related to the tidal bathymetry of the basins in which the beds occur. In a shallow bay with a gradual slope to deeper waters, such as the Chesapeake Bay, even a moderate increase in water clarity can result in tremendous increases in the areal extent of bay grasses.

Historical Underwater Bay Grass Distribution

The distribution and, therefore, the depth of historical underwater bay grass beds were mapped from photographs dating from the late 1930s through the mid-1960s by scientists at the Maryland Department of Natural Resources and the Virginia Institute of Marine Science. Historical underwater bay grass distribution data from Maryland and Virginia were aggregated into a single data set using ArcInfo GIS software. The two states' approaches reflect differences in the quality and quantity of historical aerial photographs available for interpretation. Full documentation of the methods employed and the detailed results are reported in Moore et al. (1999, 2001) and Naylor et al. (2002).

To determine historic underwater bay grass acreage, aerial photos of Maryland's portion of the

Bay taken in 1938, 1952, 1957 and 1964 were evaluated to determine the year in which the most underwater bay grass was visible for each area (Naylor 2002). The photos for the year of greatest abundance in each area were then scanned, geo-referenced and photo-interpreted to determine the extent of underwater bay grass beds during these years.

In the Virginia portion of the Chesapeake Bay and its tidal tributaries, historical underwater bay grass acreage in the James River was mapped using photographs taken in 1937, 1947, 1948, 1953, 1954, 1958, 1959, 1963, 1968, 1969, 1970 and 1973, with the historical coverage defined by the composite of the individual years (Moore et al. 1999). Historical and recent ground survey results were superimposed on the maps of historical underwater bay grass distributions to help determine whether the patterns exhibited in the photographs were actually those of underwater bay grass beds (Moore et al. 1999).

For the Rappahannock and York rivers and the adjacent smaller western shore rivers, creeks and embayments, a series of photographs from 1952 to 1956 was chosen to delineate the maximum coverage of bay grasses in these areas (Moore et al. 2001). The 1936 and 1937 photographs of these rivers showed less underwater bay grass coverage compared to the 1950s photographs. The difference appeared to be related to poorer overall atmospheric and water clarity conditions (Moore et al. 2001).

The interpretation of these historic aerial photographs closely followed current methods to delineate underwater bay grass beds throughout the Chesapeake Bay and its tidal tributaries through annual aerial underwater bay grass surveys (e.g., Orth et al. 2000). In neither state did a single year of photography provide comprehensive coverage of each state's tidal shorelines.

These state-specific analyses provide a *conservative* estimate of past underwater bay grass distributions prior to the 1970s. The conservative nature of the estimate is due, in part, because the older photographs were not collected specifically to map underwater bay grasses, but were gathered to assist in analyzing land use or farming practices. While atmospheric criteria were usually met, the factors that are important for delineating and mapping underwater bay grasses (such as tidal stage, water transparency and plant growth stage) often were not met. Underwater bay grasses likely grew at greater depths between the 1930s and 1960s, according to published and anecdotal information, than was observed in a number of segments in the historical photographs. Grasses that grow beyond the 1-meter depth contour become increasingly difficult to map, given the conditions under which the historical photographs were collected. There were limited numbers of years—often only three to five—for which historical photographs of a particular shallow-water habitat region were available for interpretation and mapping between the 1930s and early 1970s. Evidence suggests that underwater bay grass distributions already had declined by the time photographs of suitable quality were available for interpretation (Moore et al. 1999). All of these factors led to conservative estimates of past underwater bay grasses distributions and depths of bed growth.

Underwater Bay Grass No-Grow Zones

A series of underwater bay grass ‘no-grow zones’ were originally delineated in 1992 in the *Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis* (Batiuk et al. 1992). Habitats exposed to high wave energy or that have undergone physical modifications such that they could not support underwater bay grasses growth were excluded based on an extensive review of data available at the time. With the mapping of historical underwater bay grass distributions, a composite of available distribution data from the 1930s through 2001 was superimposed on the 1992 bay grass no-grow zones. A number of shoreline habitats previously considered no-grow zones showed clear evidence of historical underwater bay grass growth and, therefore, their no-grow zone designation was dropped. These revised underwater bay grass no-grow zones also include areas where the no-grow zone applies to a 1- to 2-meter depth contour as well as a 0- to 2-meter depth contour.

The revised underwater bay grass no-grow zones illustrated in Figure IV-29 show shoreline habitats of 2 meters or less where underwater bay grasses are never expected to grow due to:

- Extreme physical wave energy, which prevents the plants from rooting in the bottom sediments (e.g., Calvert Cliffs on Maryland’s lower western shore and Willoughby Split to Cape Henry near the Chesapeake Bay mouth in Virginia);

- Permanent physical alterations to nearshore habitats, including dredging close to shore accompanied by hardening of the shoreline and installation of permanent structures (i.e., shipping terminals) as observed in the inner Baltimore Harbor and the Elizabeth River;

- Natural, extreme discoloration of the water from tidal-fresh wetlands (e.g., tidal-fresh ‘blackwater’ rivers on the Eastern Shore); or

- No functional shallow-water habitat due to natural river channeling (e.g., tidal headwaters of several lower Eastern Shore rivers).

These underwater bay grass no-grow zones reflect the full set of findings on underwater bay grasses distributions from the historical (select years from the 1930s–early 1970s) and 1978–2001 data records, as well as altered nearshore/shoreline habitats as described above. The no-grow zones illustrated in Figure IV-29 are based on the best available information and are subject to future revision based on new research and information.

If no physical reasons prevent underwater bay grasses from growing in a specific shallow-water habitat, it should be expected that grasses can grow there, given appropriate water quality conditions and local sources of propagules (i.e., reproductive vegetative materials such as seeds and rhizomes). For example, evidence exists of underwater bay grasses growing within estuarine turbidity maximum zones in the upper Chesapeake Bay mainstem and selected tidal tributaries (e.g., the Potomac River), but not in other tidal tributaries. The *Regional Criteria* provides specific guidance to the states on how to address estuarine turbidity maximum zones in applying the Chesapeake Bay water clarity criteria (see Chapter VII in U.S. EPA 2003). The lack of historical data on the presence of underwater bay grasses in a particular habitat is not a valid reason to delineate that shallow-water area as an underwater bay grass no-grow zone.

Six Chesapeake Bay Program segments were not assigned a shallow-water bay grass designated use depth boundary (see Table IV-13). The established bay grass no-grow zones covered the 2-meter and less habitats along the entire tidal shoreline in each of these segments–upper Choptank River, upper Pocomoke River, Western Branch Elizabeth River, Southern Branch Elizabeth River, Eastern Branch Elizabeth River and Lafayette River (see Appendix C).

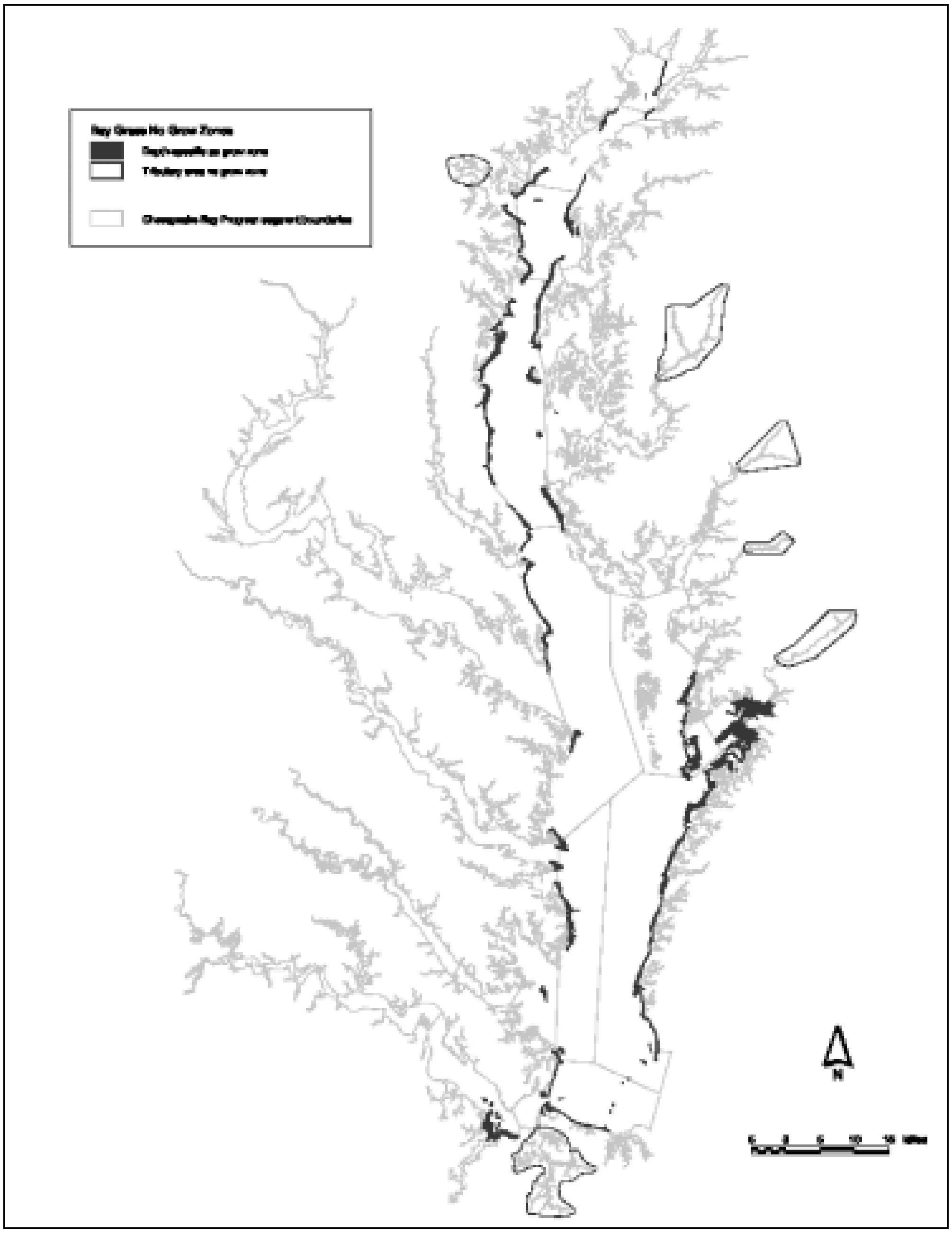

Figure IV-29. Map illustrating the revised underwater bay grass no-grow zones of the Chesapeake Bay and its tidal tributaries.

Determining the Maximum Depth of Persistent/Abundant Plant Growth

The first step in the process to define the maximum depth of persistent and abundant underwater bay grass beds by Chesapeake Bay Program segment (Table IV-11, Figure IV-30) was to establish decision rules. The rules developed take full advantage of the entire record of underwater bay grass distribution and abundance survey data and reflect the findings published in scientific literature (Table IV-12). Also, the decision rules help ensure full consistency between the establishment of the shallow-water bay grass designated use depths (the depth at which the Chesapeake Bay water clarity criteria will be applied) and the new quantitative underwater bay grasses acreage restoration goal for Chesapeake Bay and its tidal tributaries.

The available data record included interpreted aerial photography from the 1930s to the early 1970s as well as the annual baywide aerial survey data from 1978-2000. From these photos and surveys, the acreage of underwater bay grasses within three depth intervals was calculated for every Chesapeake Bay Program segment: 0-0.5 meters, > 0.5-1 meter and > 1-2 meters (Appendix B, Table B-1). Thus, each Chesapeake Bay Program segment has three 'segment-depth intervals' (e.g., CB4MH 1-2 meter is a segment-depth interval).

The total surface area within each segment-depth interval is an estimate of the area of potential underwater bay grass habitat in that segment-depth interval, minus any delineated underwater bay grass no-grow zones. Thus, there is an acreage of potential habitat for each of the three segment-depth intervals in every Chesapeake Bay Program segment except for those segments that are entirely no-grow zones (Appendix C, Table C-1).

The decision rules described in Table IV-12 are based on the observed single best year of underwater bay grass coverage for each Chesapeake Bay Program segment (i.e., not the single best year by segment-depth) (Appendix B, Table B-2). Using each segment's single best year, the percentage of available habitat at each segment-depth interval that was occupied by underwater bay grasses in that single best year was calculated (Appendix B, Table B-3). That percentage is a measure of the relative importance of each segment-depth interval as bay grass habitat. Upon application of the decision rules (Table IV-12), a set of Chesapeake Bay Program segment-specific shallow-water designated use depths was generated (Table IV-13).

Table IV-11. Chesapeake Bay Program segmentation scheme segments.

Segment	Code	Segment	Code
Northern Chesapeake Bay	CB1TF	Mobjack Bay	MOBPH
Upper Chesapeake Bay	CB2OH	Upper James River	JMSTF
Upper Central Chesapeake Bay	CB3MH	Appomattox River	APPTF
Middle Central Chesapeake Bay	CB4MH	Middle James River	JMSOH
Lower Central Chesapeake Bay	CB5MH	Chickahominy River	CHKOH
Western Lower Chesapeake Bay	CB6PH	Lower James River	JMSMH
Eastern Lower Chesapeake Bay	CB7PH	Mouth of the James River	JMSPH
Mouth of Chesapeake Bay	CB8PH	Western Branch Elizabeth River	WBEMH
Bush River	BSHOH	Southern Branch Elizabeth River	SBEMH
Gunpowder River	GUNOH	Eastern Branch Elizabeth River	EBEMH
Middle River	MIDOH	Lafayette River	LAFMH
Back River	BACOH	Mouth to mid-Elizabeth River	ELIPH
Patapsco River	PATMH	Lynnhaven River	LYNPH
Magothy River	MAGMH	Northeast River	NORTF
Severn River	SEVMH	C&D Canal	C&DOH
South River	SOUMH	Bohemia River	BOHOH
Rhode River	RHDMH	Elk River	ELKOH
West River	WSTMH	Sassafras River	SASOH
Upper Patuxent River	PAXTF	Upper Chester River	CHSTF
Western Branch Patuxent River	WBRTF	Middle Chester River	CHSOH
Middle Patuxent River	PAXOH	Lower Chester River	CHSMH
Lower Patuxent River	PAXMH	Eastern Bay	EASMH
Upper Potomac River	POTTF	Upper Choptank River	CHOTF
Anacostia River	ANATF	Middle Choptank River	CHOOH
Piscataway Creek	PISTF	Lower Choptank River	CHOMH1
Mattawoman Creek	MATTF	Mouth of the Choptank River	CHOMH2
Middle Potomac	POTOH	Little Choptank River	LCHMH
Lower Potomac	POTMH	Honga River	HNGMH
Upper Rappahannock River	RPPTF	Fishing Bay	FSBMH
Middle Rappahannock River	RPPOH	Upper Nanticoke River	NANTF
Lower Rappahannock River	RPPMH	Middle Nanticoke River	NANOH
Corrotoman River	CRRMH	Lower Nanticoke River	NANMH
Piankatank River	PIAMH	Wicomico River	WICMH
Upper Mattaponi River	MPNTF	Manokin River	MANMH
Lower Mattaponi River	MPNOH	Big Annemessex River	BIGMH
Upper Pamunkey River	PMKTF	Upper Pocomoke River	POCTF
Lower Pamunkey River	PMKOH	Middle Pocomoke River	POCOH
Middle York River	YRKMH	Lower Pocomoke River	POCMH
Lower York River	YRKPH	Tangier Sound	TANMH

Source: Chesapeake Bay Program 1999.

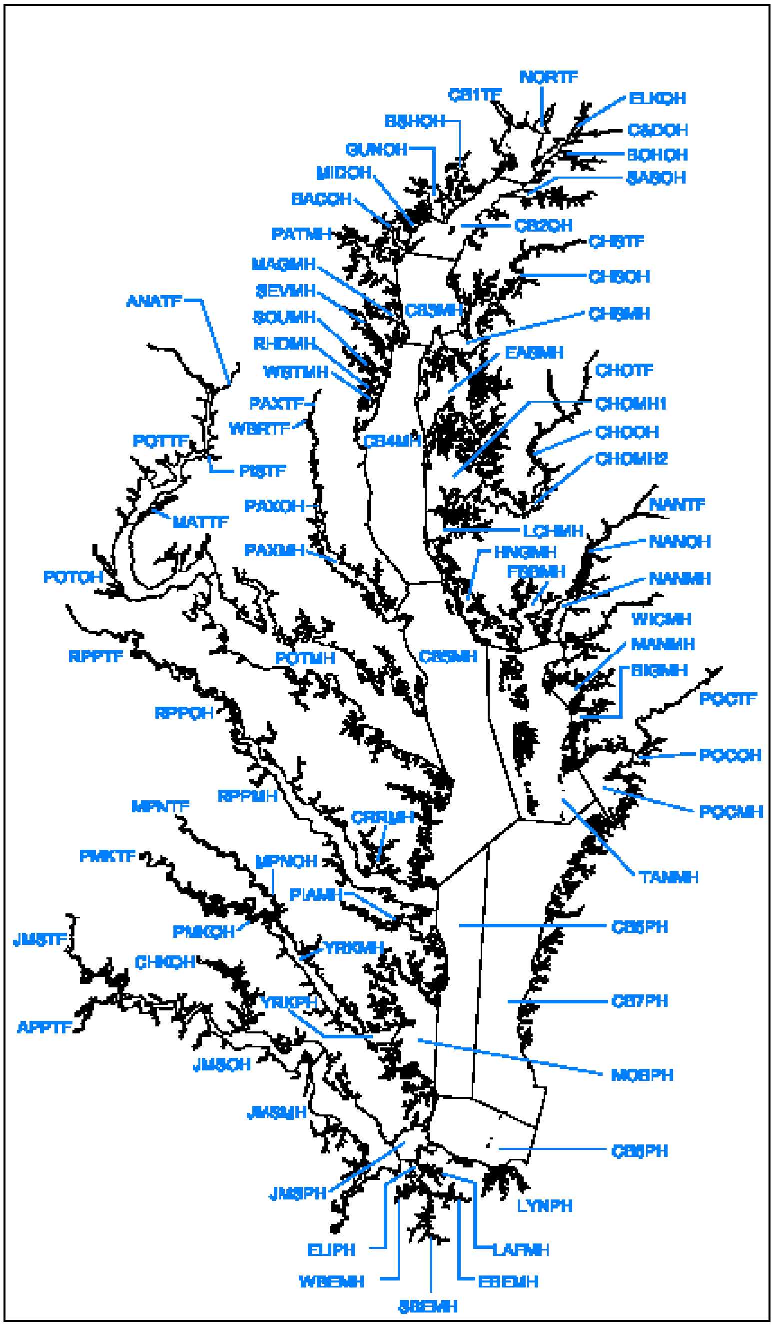

Figure IV-30. The geographical location of the 78 Chesapeake Bay Program Segments.

Source: Chesapeake Bay Program 1999.

Table IV-12. Methodology used in determining the shallow-water bay grass designated use depths by Chesapeake Bay Program segment, which led to the establishment of the 185,000 Chesapeake Bay baywide underwater grasses restoration goal.

The baywide underwater bay grass goal acreage was established based on the single best year acreage out to a shallow-water bay grass designated use depth determined as follows: 1. Bathymetry data and aerial photographs were used to divide the mapped single best year underwater bay grasses acreage in each Chesapeake Bay Program segment into three depth zones: 0-0.5 meters, > 0.5-1 meters and >1-2 meters. The delineated underwater bay grass no-grow zones were then removed from consideration as shallow-water bay grass designated use habitat. 2. The aerial photographs were used to determine the depth to which the mapped underwater bay grass beds grew in each Chesapeake Bay Program segment with either a minimum abundance or minimum persistence. The underwater bay grass goal for a Chesapeake Bay Program segment is the portion of the single best year acreage mapped out to the higher depth in the determined depth range. The decision rules for this were as follows: In all segments, the 0-0.5 meter depth interval was designated for shallow-water bay grass use. In addition, the shallow-water bay grass use was designated for deeper depths within a Chesapeake Bay Program segment if either: A) The single best year of underwater bay grasses distribution covered at least 20 percent of the potential habitat in a deeper depth interval; or, B) The single best year of underwater bay grass distribution covered at least 10 percent of the potential habitat in the segment-depth interval, and at least three of the four five-year periods of the more recent record (1978-2000) showed at least 10 percent underwater bay grasses coverage of potential habitat in the segment-depth interval. 3. The single best year underwater bay grasses distribution acreage of all Chesapeake Bay Program segments were clipped at the deeper depth of the segment-depth interval determined above. The resulting underwater bay grass acreage for each segment were added, resulting in the total baywide underwater bay grass acreage goal of 185,000 acres.

Table IV-13. The single best year and maximum depth interval for applying the water clarity criteria used in determining the Chesapeake Bay Program segment-specific shallow-water underwater bay grass designated use boundary depths.

Chesapeake Bay Program (CBP) Segment Name	CBP Segment	Single Best Year	Maximum Depth Interval Application of the Water Clarity Criteria (meters)			Recom-mended Shallow Water Designated Use Depth (meters)
			0–0.5	0.5–1	1–2	
Northern Chesapeake Bay	CB1TF	Historical				2
Upper Chesapeake Bay	CB2OH	Historical				0.5
Upper Central Chesapeake Bay	CB3MH	1978				0.5
Middle Central Chesapeake Bay	CB4MH	Historical				2
Lower Central Chesapeake Bay	CB5MH	Historical				2
Western Lower Chesapeake Bay	CB6PH	Historical				1
Eastern Lower Chesapeake Bay	CB7PH	Historical				2
Mouth of the Chesapeake Bay	CB8PH	1996				0.5
Bush River	BSHOH	Historical				0.5
Gunpowder River	GUNOH	2000				2
Middle River	MIDOH	Historical				2
Back River	BACOH	*				0.5
Patapsco River	PATMH	Historical				1
Magothy River	MAGMH	Historical				1
Severn River	SEVMH	1999				1
South River	SOUMH	Historical				1
Rhode River	RHDMH	Historical				0.5
West River	WSTMH	Historical				0.5
Upper Patuxent River	PAXTF	1996				0.5
Western Branch (Patuxent River)	WBRTF	*				0.5
Middle Patuxent River	PAXOH	2000				0.5
Lower Patuxent River	PAXMH	Historical				1
Upper Potomac River	POTTF	1991				2
Anacostia River	ANATF	1991				0.5
Piscataway Creek	PISTF	1987				2
Mattawoman Creek	MATTF	2000				1
Middle Potomac River	POTOH	1998				2
Lower Potomac River	POTMH	Historical				1
Upper Rappahannock River	RPPTF	2000				0.5
Middle Rappahannock River	RPPOH	*				0.5
Lower Rappahannock River	RPPMH	Historical				1
Corrotoman River	CRRMH	Historical				1
Piankatank River	PIAMH	Historical				2

Chesapeake Bay Program (CBP) Segment Name	CBP Segment	Single Best Year	Maximum Depth Interval Application of the Water Clarity Criteria (meters) 0–0.5	0.5–1	1–2	Recom-mended Shallow Water Designated Use Depth (meters)
Upper Mattaponi River	MPNTF	1998				0.5
Lower Mattaponi River	MPNOH	*				0.5
Upper Pamunkey River	PMKTF	1998				0.5
Lower Pamunkey River	PMKOH	*				0.5
Middle York River	YRKMH	Historical				0.5
Lower York River	YRKPH	Historical				1
Mobjack Bay	MOBPH	Historical				2
Upper James River	JMSTF	Historical				0.5
Appomattox River	APPTF	Historical				0.5
Middle James River	JMSOH	1998				0.5
Chickahominy River	CHKOH	2000				0.5
Lower James River	JMSMH	Historical				0.5
Mouth of the James River	JMSPH	Historical				1
Western Branch Elizabeth River	WBEMH	*				*
Southern Branch Elizabeth River	SBEMH	*				*
Eastern Branch Elizabeth River	EBEMH	*				*
Lafayette River	LAFMH	*				*
Mouth to mid- Elizabeth River	ELIPH	*				*
Lynnhaven River	LYNPH	1986				0.5
Northeast River	NORTF	Historical				0.5
C&D Canal	C&DOH	1978				0.5
Bohemia River	BOHOH	2000				0.5
Elk River	ELKOH	2000				2
Sassafras River	SASOH	2000				1
Upper Chester River	CHSTF	*				0.5
Middle Chester River	CHSOH	Historical				0.5
Lower Chester River	CHSMH	Historical				1
Eastern Bay	EASMH	Historical				2
Upper Choptank River	CHOTF	*				*
Middle Choptank River	CHOOH	Historical				0.5
Lower Choptank River	CHOMH2	Historical				1
Mouth of the Choptank River	CHOMH1	Historical				2
Little Choptank River	LCHMH	Historical				2
Honga River	HNGMH	Historical				2
Fishing Bay	FSBMH	Historical				0.5
Upper Nanticoke River	NANTF	*				0.5

Chesapeake Bay Program (CBP) Segment Name	CBP Segment	Single Best Year	Maximum Depth Interval Application of the Water Clarity Criteria (meters)			Recom-mended Shallow Water Designated Use Depth (meters)
			0–0.5	0.5–1	1–2	
Middle Nanticoke River	NANOH	Historical				0.5
Lower Nanticoke River	NANMH	Historical				0.5
Wicomico River	WICMH	Historical				0.5
Manokin River	MANMH	Historical				2
Big Annemessex River	BIGMH	Historical				2
Upper Pocomoke River	POCTF	*				*
Middle Pocomoke River	POCOH	*				0.5
Lower Pocomoke River	POCMH	Historical				1
Tangier Sound	TANMH	Historical				2

Decision rules not met – default depth interval of 0-0.5 meters applies.

Single best year percent of total potential habitat is $20 percent.

Percent of total potential habitat is 10-19.9% and underwater bay grasses are persistent (1978–2000).

Chesapeake Bay Program segment completely within the underwater bay grass no-grow zone.

*Denotes no data available or no underwater bay grasses mapped (1930s-2000).

Rationale for the 20 Percent and 10 Percent Rules

In setting application depths, it was important to select a percentage of cover high enough to assure that underwater plants definitely occupied that habitat, but low enough that the resulting depths realistically represented true light availability attained during the available historical data record. Underwater bay grass beds in tidal waters of the Chesapeake Bay display a spatial heterogeneity that is characteristic of underwater grass beds elsewhere in the world (Lehmann et al.1997; Kuenen and Debrot 1995; Carpenter and Titus 1984). This heterogeneity exists both in micro and macro scales, and as viewed by aerial photography results in a spatial distribution that is virtually never 100 percent coverage of available shallow-water habitat at any depth. This growth pattern was true historically as well. Manning (1957) estimated that lower Patuxent River underwater bay grass beds covered only about one-third of shoal waters. Photography from Maryland from 1938 and 1952 revealed an average percent cover of 35 percent (Naylor 2002) at depths of less than 1 meter. Virginia photographic analysis revealed up to 48 percent coverage in the York and Rappahannock rivers at the less than 1-meter depth (Moore et al. 2001). These findings were supported by similar findings from analysis of the more recent 1978-2000 Chesapeake Bay underwater bay grass aerial survey distribution data.

Several possible reasons account for less-than-complete habitat occupation. These include small-scale sediment type differences, small-scale sediment movement patterns, sediment slope, fetch, uneven seed distribution and localized disturbance. In addition to these reasons for real variations in plant presence, only the most dense areas of underwater bay grasses are visible using high-altitude photography. Very sparse beds reveal no signature in the water and are never delineated through photo interpretation. Each year, Chesapeake Bay researchers and resource managers find dozens of underwater bay grass beds in places not identified in the annual aerial survey due to these limitations. Thus, reporting of percent coverage is generally lower than the total amount of habitat actually occupied by sparse plant beds, which further lowers the total percent coverage. Given the starting point of 1 percent, and the typical maximum of 35-48 percent from the historical photography, 20 percent was seen as a defensible midpoint figure reflective of sufficient coverage to define maximum depth of the underwater bay grasses growth (Moore 1999, 2001; Naylor 2002).

In order to provide an additional measure of the importance of a segment-depth interval as underwater bay grass habitat, the record of underwater bay grass aerial survey data from 1978–2000 (there is not a survey for every year between 1979-1983 and in 1988) was segmented into four five-year intervals (Appendix B, Table B-4). The persistence of underwater bay grasses in each segment-depth interval was then assessed by counting the number of five-year intervals in which at least 10 percent of potential habitat was occupied by underwater bay grasses.

Underwater Bay Grass Restoration Goal-Based Boundaries

The *Chesapeake 2000* agreement committed to revising the existing underwater bay grass restoration goals and strategies:

> *... to reflect historic abundance, measured as acreage and density from the 1930s to present. The revised goals will include specific levels of water clarity which are to be met in 2010. Strategies to achieve these goals will address water clarity, water quality and bottom disturbance.*

The eligible segments and depths included in calculating the new underwater bay grass restoration goal were limited to segment-depth intervals designated for shallow-water bay grass use. The new restoration goal was derived from the total single best year acreage summed over all the segment-depths that were designated for shallow-water bay grass use after considering a wide array of data and information (Figure IV-31).

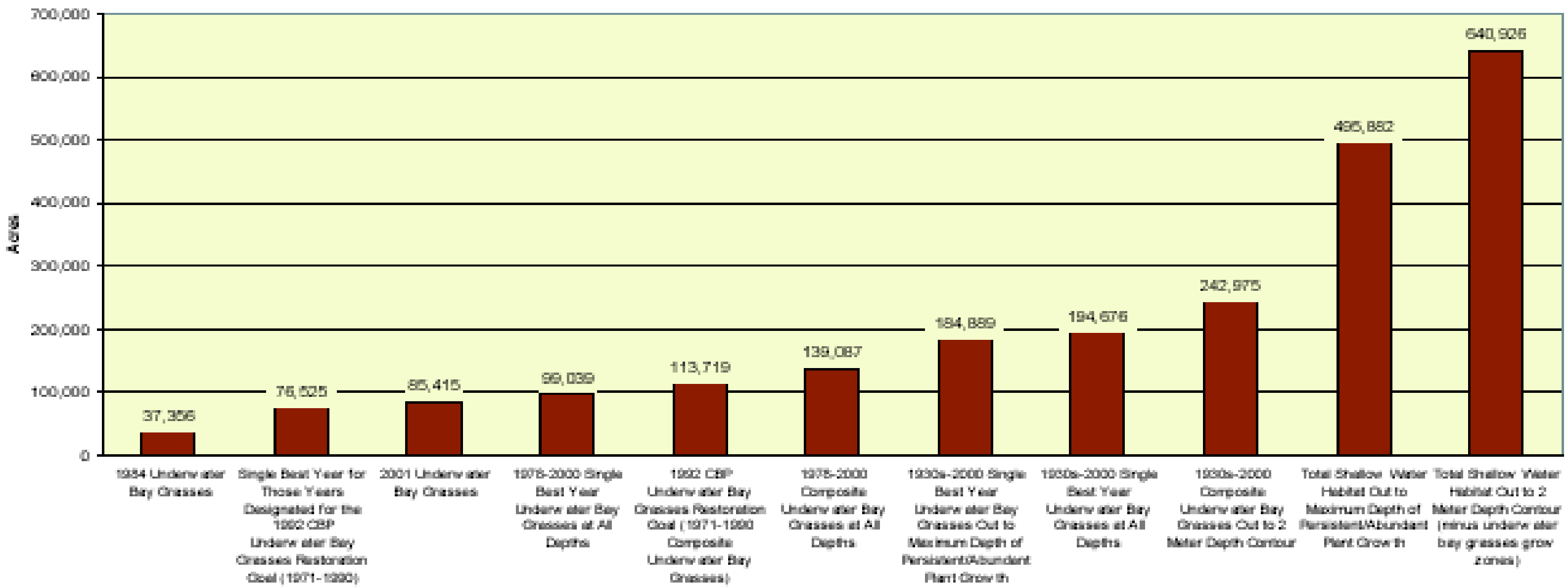

Figure IV-31. Array of different underwater bay grass and shallow-water habitat acreages considered during the process for setting the shallow-water designated use depths and establishing the new Chesapeake Bay underwater bay restoration goal.

Sources: Moore et al. 1999, 2001; Naylor 2002; Virginia Institute of Marine Science Chesapeake Bay SAV website http://www.vims.edu/bio/sav; Chesapeake Bay Program website http://www.chesapeakebay.net.

Data Used to Establish the Restoration Goal

It was essential to use historical underwater bay grass data in determining the underwater bay grass acreage goal for the Chesapeake Bay. But using these data presented obvious limitations. They were originally collected for agricultural landuse mapping purposes and thus did not include all areas of tidal shallow-water habitats, which resulted in an underestimate of the mapped acreage. Historic data also were limited by the fact that pre-Hurricane Agnes (June 1972) underwater bay grass data exist only for a limited number of years in each Chesapeake Bay Program segment. Thus, using only historical data to determine a new goal would likely underestimate the potential for underwater bay grass recovery.

Rationale for Use of the Single Best Year

The single best year of underwater bay grass growth observed in each Chesapeake Bay Program segment from the entire available record of aerial photographs (1930s-2000) is the best available data on underwater bay grass occurrence over the long-term. Of the 62 Chesapeake Bay Program segments with mapped underwater bay grasses, 68 percent of the segment single best year acreages occurred in the 1930s to early 1970s time period; 3 percent occurred in 1978; 5 percent occurred between 1986 and 1991; and 24 percent occurred between 1996 and 2000 (see Table IV-13).

There were several obvious benefits in using the single best year approach to setting the new restoration goal. The single best year acreage is the most solid available data on underwater bay grass acreage over the multi-decade data record. Even in suitable water quality conditions, underwater bay grass beds often move around within a segment By combining acreage over a number of years into a composite acreage it would be possible to overestimate the likely future abundance of underwater bay grasses in any single year.

Using the single best year as the basis for the new restoration goal ensures consistency with the method for determining the segment-specific shallow-water designated use depths and the resulting water clarity criteria application depths. The consistency between methods links the segment-specific water clarity application depths, shallow-water designated use boundaries and underwater bay grass restoration goals. This method is scientifically valid because when the acreage goals for segments in the same salinity range are totaled (see “Shallow-Water Habitat-Based Boundaries,” below), the percentage of available habitat covered by the restoration goal acreage is consistent with the average rate of habitat occupancy described in the scientific literature as reflecting healthy underwater bay grass growth.

The new underwater bay grass goal focuses the restoration effort on areas that demonstrated a minimal level of abundance or persistence in the past and which are likely to respond to water clarity improvements in the future. Focusing on the single best year versus a composite underwater bay grass coverage ensures that vegetated portions of potential underwater bay grass habitats are not over-accounted-for based on underwater bay grass beds that may have ‘migrated’ year-to-year over the past seven decades.

New Underwater Bay Grass Restoration Goal

Table IV-14 lists the Chesapeake Bay Program segment-specific single best year acreage within the shallow-water bay grasses designated use depths that, added together, make up the baywide 185,000 acre restoration goal.

Table IV-14. Chesapeake Bay underwater bay grass restoration goals by Chesapeake Bay Program segment.

Segment Name	Segment	Single Best Year	Acres
Northern Chesapeake Bay	CB1TF	Historical	12,908
Upper Chesapeake Bay	CB2OH	Historical	302
Upper Central Chesapeake Bay	CB3MH	1978	943
Middle Central Chesapeake Bay	CB4MH	Historical	2,511
Lower Central Chesapeake Bay	CB5MH	Historical	14,961
Western Lower Chesapeake Bay	CB6PH	Historical	980
Eastern Lower Chesapeake Bay	CB7PH	Historical	14,620
Mouth of the Chesapeake Bay	CB8PH	1996	6
Bush River	BSHOH	Historical	158
Gunpowder River	GUNOH	2000	2,254
Middle River	MIDOH	Historical	838
Back River	BACOH	*	0
Patapsco River	PATMH	Historical	298
Magothy River	MAGMH	Historical	545
Severn River	SEVMH	1999	329
South River	SOUMH	Historical	459
Rhode River	RHDMH	Historical	48
West River	WSTMH	Historical	214
Upper Patuxent River	PAXTF	1996	5
Western Branch (Patuxent River)	WBRTF	*	0
Middle Patuxent River	PAXOH	2000	68
Lower Patuxent River	PAXMH	Historical	1,325
Upper Potomac River	POTTF	1991	4,368
Anacostia River	ANATF	1991	6
Piscataway Creek	PISTF	1987	783
Mattawoman Creek	MATTF	2000	276
Middle Potomac River	POTOH	1998	3,721
Lower Potomac River	POTMH	Historical	10,173
Upper Rappahannock River	RPPTF	2000	20
Middle Rappahannock River	RPPOH	*	0
Lower Rappahannock River	RPPMH	Historical	5,380
Corrotoman River	CRRMH	Historical	516

Segment Name	Segment	Single Best Year	Acres
Piankatank River	PIAMH	Historical	3,256
Upper Mattaponi River	MPNTF	1998	75
Lower Mattaponi River	MPNOH	*	0
Upper Pamunkey River	PMKTF	1998	155
Lower Pamunkey River	PMKOH	*	0
Middle York River	YRKMH	Historical	176
Lower York River	YRKPH	Historical	2,272
Mobjack Bay	MOBPH	Historical	15,096
Upper James River	JMSTF	Historical	1,600
Appomattox River	APPTF	Historical	319
Middle James River	JMSOH	1998	7
Chickahominy River	CHKOH	2000	348
Lower James River	JMSMH	Historical	531
Mouth of the James River	JMSPH	Historical	604
Western Branch Elizabeth River	WBEMH	*	0
Southern Branch Elizabeth River	SBEMH	*	0
Eastern Branch Elizabeth River	EBEMH	*	0
Lafayette River	LAFMH	*	0
Mouth to mid-Elizabeth River	ELIPH	*	0
Lynnhaven River	LYNPH	1986	69
Northeast River	NORTF	Historical	88
C&D Canal	C&DOH	1978	0
Bohemia River	BOHOH	2000	97
Elk River	ELKOH	2000	1,648
Sassafras River	SASOH	2000	764
Upper Chester River	CHSTF	*	0
Middle Chester River	CHSOH	Historical	63
Lower Chester River	CHSMH	Historical	2,724
Eastern Bay	EASMH	Historical	6,108
Upper Choptank River	CHOTF	*	0
Middle Choptank River	CHOOH	Historical	63
Lower Choptank River	CHOMH2	Historical	1,499
Mouth of the Choptank River	CHOMH1	Historical	8,044
Little Choptank River	LCHMH	Historical	3,950

Segment Name	Segment	Single Best Year	Acres
Honga River	HNGMH	Historical	7,686
Fishing Bay	FSBMH	Historical	193
Upper Nanticoke River	NANTF	*	0
Middle Nanticoke River	NANOH	Historical	3
Lower Nanticoke River	NANMH	Historical	3
Wicomico River	WICMH	Historical	3
Manokin River	MANMH	Historical	4,359
Big Annemessex River	BIGMH	Historical	2,014
Upper Pocomoke River	POCTF	*	0
Middle Pocomoke River	POCOH	*	0
Lower Pocomoke River	POCMH	Historical	4,092
Tangier Sound	TANMH	Historical	37,965
Total acres			**184,889**

*No underwater grasses recorded for any year within the available 1930s-2000 data record.

Shallow-Water Habitat Area to Support Restoration Goal-Based Boundaries

As described previously, the restoration of underwater bay grasses within a segment requires that shallow-water habitat meet the Chesapeake Bay water clarity criteria over a greater acreage than the underwater bay grasses will actually cover. The ratio of underwater bay grass acreage to the required shallow-water habitat acreage varies based on the different species of underwater bay grasses that inhabit the Bay's four salinity regimes. Shallow-water habitat acreage ratios have been derived scientifically through evaluation of extensive underwater bay grasses distribution data within tidal fresh, low, medium and high salinity regimes (reflecting different levels of coverage by different underwater bay grass communities).

The Chesapeake Bay Program segment-specific restoration goal acreage and corresponding shallow-water designated use acreage (to the previously determined maximum depth of abundant and persistent underwater plant growth) listed in Table IV-15 were summed by major salinity regime–tidal fresh (0-0.5 ppt), oligohaline (> 0.5-5 ppt), mesohaline (> 5ppt-18 ppt) and polyhaline (>18 ppt).[1] The underwater bay grasses acreage to shallow-water habitat acreage ratios were then expressed as a percentage of the total shallow-water designated use habitat. Compared with a baywide value of 38 percent, the tidal-fresh (37 percent), mesohaline (39 percent) and polyhaline (41 percent) values were all very close to the baywide value as well as

[1] Note that all Chesapeake Bay Program segments h ave been assigned to one of the four salinity regimes based on an evaluation of almost two decades of salinity data. The segment-naming convention documents each individual segment's long-term averaged respective salinity regime: TF = tidal fresh, OH = oligohaline, MH = mesohaline and PH = polyhaline.

the other salinity regime-specific values (Table IV-16). These values are consistent with findings published in the scientific literature and the 35 to 48 percent range derived from evaluation of the 1930s through early 1970s historical data record by Naylor (2002) and Moore (1999, 2001). Influenced by the natural presence of the estuarine turbidity maximum, the value was 21 percent in oligohaline habitats.

Table IV-15. Summary of underwater bay grass and shallow-water designated use acreage and goals.

Chesapeake Bay Program Segment Name	CBP Segment	2001 Underwater Bay Grass Acreage	Existing Use Acreage (1978-2001 Single Best Year)	Restoration Goal Acreage	Shallow-Water Acreage to Maximum Depth of Persistent/Abundant Plant Growth	Percent Shallow-Water Designated Use Habitat Covered by Restoration Goal Acreage	Shallow-Water Designated Use Depth
Northern Chesapeake Bay	CB1TF	7979	7773	12,908	20,907	61.7	2
Upper Chesapeake Bay	CB2OH	203	640	302	2405	12.5	0.5
Upper Central Chesapeake Bay	CB3MH	1	1,296	943	2,011	46.9	0.5
Middle Central Chesapeake Bay	CB4MH	112	176	2,511	10,630	23.6	2
Lower Central Chesapeake Bay	CB5MH	4,487	4,240	14,961	29,959	49.9	2
Western Lower Chesapeake Bay	CB6PH	715	1,208	980	3,939	24.9	1
Eastern Lower Chesapeake Bay	CB7PH	9,168	10,729	14,620	33,304	43.9	2
Mouth of the Chesapeake Bay	CB8PH	8	11	6	381	1.5	0.5
Bush River	BSHOH	3	187	158	1,136	13.9	0.5
Gunpowder River	GUNOH	*	2,281	2,254	7,358	30.6	2
Middle River	MIDOH	*	698	838	2,479	33.8	2
Back River	BACOH	*	0	0	850	0.0	0.5
Patapsco River	PATMH	*	114	298	1,802	16.6	1

Chesapeake Bay Program Segment Name	CBP Segment	2001 Underwater Bay Grass Acreage	Existing Use Acreage (1978-2001 Single Best Year)	Restoration Goal Acreage	Shallow-Water Acreage to Maximum Depth of Persistent/Abundant Plant Growth	Percent Shallow-Water Designated Use Habitat Covered by Restoration Goal Acreage	Shallow-Water Designated Use Depth
Magothy River	MAGMH	*	427	545	1,378	39.6	1
Severn River	SEVMH	120	433	329	1347	24.4	1
South River	SOUMH	27	50	459	1,432	32.1	1
Rhode River	RHDMH	*	14	48	267	18.0	0.5
West River	WSTMH	*	106	214	542	39.5	0.5
Upper Patuxent River	PAXTF	205	44	5	24	22.2	0.5
Western Branch (Patuxent River)	WBRTF	*	0	0	0	0.0	0.5
Middle Patuxent River	PAXOH	104	80	68	1,072	6.3	0.5
Lower Patuxent River	PAXMH	22	108	1,325	5121	25.9	1
Upper Potomac River	POTTF	1,964	4,465	4368	17,501	25.0	2
Anacostia River	ANATF	4	11	6	85	6.6	0.5
Piscataway Creek	PISTF	*	783	783	914	85.7	2
Mattawoman Creek	MATTF	*	311	276	695	39.7	1
Middle Potomac River	POTOH	3,070	3,766	3,721	15,193	24.5	2

Chesapeake Bay Program Segment Name	CBP Segment	2001 Underwater Bay Grass Acreage	Existing Use Acreage (1978-2001 Single Best Year)	Restoration Goal Acreage	Shallow-Water Acreage to Maximum Depth of Persistent/Abundant Plant Growth	Percent Shallow-Water Designated Use Habitat Covered by Restoration Goal Acreage	Shallow-Water Designated Use Depth
Lower Potomac River	POTMH	1739	2130	10173	26075	39.0	1
Upper Rappahannock River	RPPTF	66	30	20	2175	0.9	0.5
Middle Rappahannock River	RPPOH	*	0	0	1226	0	0.5
Lower Rappahannock River	RPPMH	478	841	5,380	19,793	27.2	1
Corrotoman River	CRRMH	389	419	516	1,819	28.4	1
Piankatank River	PIAMH	539	1,003	3,256	8,014	40.6	2
Upper Mattaponi River	MPNTF	*	84	75	800	9.4	0.5
Lower Mattaponi River	MPNOH	*	0	0	358	0.0	0.5
Upper Pamunkey River	PMKTF	140	184	155	1,860	8.4	0.5
Lower Pamunkey River	PMKOH	*	0	0	420	0.0	0.5
Middle York River	YRKMH	*	0	176	4,728	3.7	0.5
Lower York River	YRKPH	801	815	2272	4,949	45.9	1
Mobjack Bay	MOBPH	9,508	10,653	15096	33990	44.4	2
Upper James River	JMSTF	95	76	1,600	8,249	19.4	0.5

Chesapeake Bay Program Segment Name	CBP Segment	2001 Underwater Bay Grass Acreage	Existing Use Acreage (1978-2001 Single Best Year)	Restoration Goal Acreage	Shallow-Water Acreage to Maximum Depth of Persistent/Abundant Plant Growth	Percent Shallow-Water Designated Use Habitat Covered by Restoration Goal Acreage	Shallow-Water Designated Use Depth
Appomattox River	APPTF	*	0	319	1,085	29.4	0.5
Middle James River	JMSOH	15	8	7	3179	0.2	0.5
Chickahominy River	CHKOH	268	422	348	3283	10.6	0.5
Lower James River	JMSMH	2	3	531	9,618	5.5	0.5
Mouth of the James River	JMSPH	232	231	604	1,616	37.4	1
Western Branch Elizabeth River	WBEMH	*	0	0	0	0.0	*
Southern Branch Elizabeth River	SBEMH	*	0	0	0	0.0	*
Eastern Branch Elizabeth River	EBEMH	*	0	0	0	0.0	*
Lafayette River	LAFMH	*	0	0	0	0.0	*
Mouth of the Elizabeth River	ELIPH	*	0	0	0	0.0	*
Lynnhaven River	LYNPH	43	105	69	2476	2.8	0.5
Northeast River	NORTF	*	19	88	456	19.3	0.5
C&D Canal	C&DOH	7	5	0	99	0.2	0.5
Bohemia River	BOHOH	354	330	97	735	13.2	0.5

Chesapeake Bay Program Segment Name	CBP Segment	2001 Underwater Bay Grass Acreage	Existing Use Acreage (1978-2001 Single Best Year)	Restoration Goal Acreage	Shallow-Water Acreage to Maximum Depth of Persistent/Abundant Plant Growth	Percent Shallow-Water Designated Use Habitat Covered by Restoration Goal Acreage	Shallow-Water Designated Use Depth
Elk River	ELKOH	2034	2006	1,648	5,024	32.8	2
Sassafras River	SASOH	1,169	1,116	764	2614	29.2	1
Upper Chester River	CHSTF	*	0	0	574	0	0.5
Middle Chester River	CHSOH	*	0	63	926	6.8	0.5
Lower Chester River	CHSMH	205	2,369	2,724	6,980	39	1
Eastern Bay	EASMH	2,886	4,610	6,108	20,805	29.4	2
Upper Choptank River	CHOTF	*	0	0	0	0.0	*
Middle Choptank River	CHOOH	*	0	63	591	10.7	0.5
Lower Choptank River	CHOMH2	148	193	1,499	3,770	39.8	1
Mouth of the Choptank River	CHOMH1	5,257	6,445	8,044	20,857	38.6	2
Little Choptank River	LCHMH	2,377	1,454	3,950	12,367	31.9	2
Honga River	HNGMH	4,945	4,656	7,686	16,456	46.7	2
Fishing Bay	FSBMH	6	59	193	2,467	7.8	0.5
Upper Nanticoke River	NANTF	*	0	0	0	0.0	*

Chesapeake Bay Program Segment Name	CBP Segment	2001 Underwater Bay Grass Acreage	Existing Use Acreage (1978-2001 Single Best Year)	Restoration Goal Acreage	Shallow-Water Acreage to Maximum Depth of Persistent/Abundant Plant Growth	Percent Shallow-Water Designated Use Habitat Covered by Restoration Goal Acreage	Shallow-Water Designated Use Depth
Middle Nanticoke River	NANOH	*	0	3	1,141	0.3	0.5
Lower Nanticoke River	NANMH	*	0	3	1583	0.2	0.5
Wicomico River	WICMH	*	0	3	1,513	0.2	0.5
Manokin River	MANMH	404	420	4,359	10,700	40.7	2
Big Annemessex River	BIGMH	721	546	2,014	5,065	39.8	2
Upper Pocomoke River	POCTF	*	0	0	0	0.0	*
Middle Pocomoke River	POCOH	*	0	0	289	0.0	0.5
Lower Pocomoke River	POCMH	1,528	1,831	4,092	9,936	41.2	1
Tangier Sound	TANMH	13,310	17,688	37,965	68,578	55.4	2
Totals		77,854	100,701	184889	491,968		

* No underwater bay grasses mapped or aerial photography collected due to 9/11/01 flight path restrictions.

Table IV-16. Percent of total shallow-water designated use habitat covered by single best year underwater bay grass acreage by salinity regime.

	Tidal-Fresh	Oligohaline	Mesohaline	Polyhaline
Median	37.2	20.5	39.2	41.3
Minimum	0	0	0.2	1.5
Maximum	85.7	33.8	54.3	45.9
No. of Segments	14	20	29	7

CONFIRMING THAT THE REFINED DESIGNATED USES MEET EXISTING USES

The EPA Water Quality Standards regulations at 40 CFR 131.10(g) and (j) specify that states may remove a designated use that is not an existing use, or establish subcategories of a use, if they can demonstrate that attaining the designated use is not feasible. The current regulation at 40 CFR Part 131 identifies the factors that must be considered in making such a demonstration. As the regulation explains, existing uses, by definition, are attainable and must be protected by designated uses in water quality standards (40 CFR 131.10[g], 131.10[h][1] and 131.10[i]). Any change in designated uses must show that the existing uses are still being protected. As the EPA 1983 Water Quality Standards Handbook describes, an existing use can be defined as fishing, swimming or other uses that have actually occurred since November 28, 1975; or the water quality that is suitable to allow the use to be attained—unless there are physical factors, such as substrate or flow, that prevent the use from being attained (U.S. EPA 1983). Section 131.12(a)(1) in turn requires state anti-degradation policies to protect existing water quality. This paragraph applies a minimum level of protection to all waters. In setting the five subcategories of current tidal-water designated uses, explicit steps were taken in developing the refined uses and their boundaries to ensure that existing aquatic life uses would continue to be protected.

Migratory Spawning and Nursery Existing Use

The migratory fish spawning and nursery designated use will be protected by a set of Chesapeake Bay-specific dissolved oxygen criteria that are more protective–6 mg/l 7-day mean and 5 mg/l instantaneous minimum–than current state water quality standards that apply to these same habitats from February 1 through May 31 (U.S. EPA 2003). Existing uses within the migratory fish spawning and nursery habitats will continue to be protected.

Shallow-Water Existing Use

In delineating the shallow-water use, the single best year of underwater bay grass distribution mapped since the 1930s was used to define a shallow-water designated use depth, underwater bay grass restoration goal and a corresponding shallow-water habitat acreage to support achievement of the restoration goal for each respective Chesapeake Bay Program segment. Most of the segment-specific restoration goal acreage is higher than the established existing use underwater bay grass acreage derived from the single best year of the 1978-2001 data record out to the maximum depth of abundant/persistent underwater plant growth (see Table IV-15). In those cases where the existing use acreage is higher than the restoration goal, the existing use acreage will drive the shallow-water designated use boundary. As most of the single best years were based on historical underwater bay grass distributions (1930s through the early 1970s), the shallow-water bay grass uses existing since 1975 will continue to be protected.

Open-Water Existing Use

The application of the open-water fish and shellfish designated use dissolved oxygen criteria will provide an equal level of protection to the same tidal waters as current state water quality standards. The combined set of 5 mg/l 30-day mean, 4 mg/l 7-day mean, and 3 mg/l instantaneous minimum have been documented to protect all life stages of open-water habitat species in the Chesapeake Bay and its tidal waters (U.S. EPA 2003). Existing uses within the open-water habitats will continue to be protected.

Deep-Water and Deep-Channel Existing Uses

The application of the deep-water seasonal fish and shellfish designated use and the deep-channel seasonal refuge designated use and their respective oxygen criteria will result in improvements to existing water quality conditions that currently do not attain the applicable criteria (see Chapter V). Given that trends in dissolved oxygen conditions have been generally degrading since the early 1970s (see Chapter III; Hagy 2002), improvements to these conditions will ensure that existing uses within the deep-water and deep-channel habitats will continue to be protected.

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